Animal Kingdom: Non-Chordates

1A
Chapter

1 INTRODUCTION

- **What is the need to classify animals?**
- Classification helps in assigning a systematic position to newly described species.
- **Characteristics of members of kingdom Animalia** –
  - Eukaryotic organisms
  - Division of labour
  - Definite growth pattern
  - Capable of locomotion
  - Multicellular and their cells lack cell wall
  - Heterotrophic with holozoic mode of nutrition
  - Sensory and neuromotor mechanism

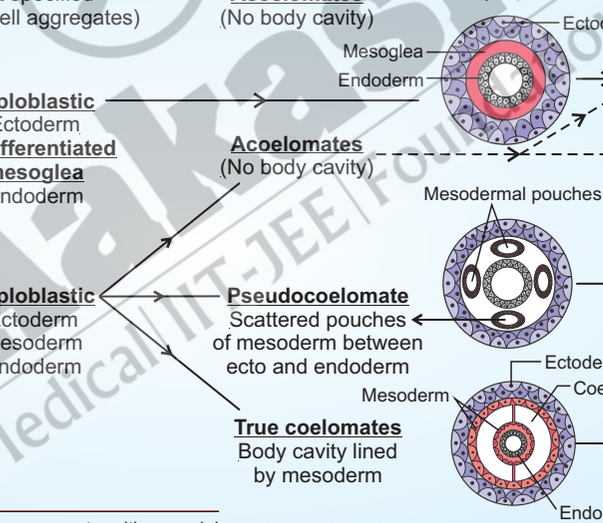
  → **With some exceptions (Poriferans)**

2 BASIS OF ANIMAL CLASSIFICATION

- There are fundamental features common to various individuals and have certain distinct characters which are specific to each phyla/class.

Broad Classification

Hierarchy	Level of Organisation	Types of Symmetry	Germ Layers	Body Cavity/Coelom (mesodermal lining)	Phylum(s)	Metamerism/ Segmentation	Notochord
Simple	Cellular	**Asymmetrical** – Any plane passing through the centre does not divide the organism into 2 equal halves	Not specified (loose cell aggregates)	**Acoelomates** (No body cavity)	Porifera	×	Absent
	Tissue	**Radial** – Any longitudinal plane passing through the central axis of the body divides the organism into 2 identical halves	**Diploblastic** – Ectoderm, **Undifferentiated mesoglea**, Endoderm	**Acoelomates** (No body cavity)	Coelenterata	×	
					Ctenophora	×	
					Platyhelminthes	×	
	Organ	**Bilateral** – Only one longitudinal plane passing through the centre of the body divides the organism into identical right and left halves	**Triploblastic** – Ectoderm, Mesoderm, Endoderm	**Pseudocoelomate** – Scattered pouches of mesoderm between ecto and endoderm	Aschelminthes	×	
Complex	Organ system (Each system with a specific physiological function)			**True coelomates** – Body cavity lined by mesoderm	Annelida	✓	
					Arthropoda	✓	
					Mollusca	×	
					Echinodermata	×	
					Hemichordata	×	
					Chordata	✓	Present



- **Metameric Segmentation** – Body is externally and internally divided into segments with a serial repetition of at least some organs
- **Notochord** – Mesodermally derived rod like structure formed on the dorsal side during embryonic development in some animals
- **Animals without notochord** – Non-chordates (Porifera to echinoderms)
- **Animals with notochord** – Chordates
- About 2/3rd of all species on earth are **Arthropods** (Most abundant are insects)

- **Some Conclusions From Classification:**
  - Poriferans are mostly asymmetrical organisms with cellular level of organisation.
  - **All diploblastic organisms have radial symmetry and are acoelomates.**
  - Bilateral symmetry is most advanced form of symmetry that arose with motile organisms.
  - **Platyhelminthes are first triploblastic, bilaterally symmetrical acoelomates.**
  - Echinoderms have radial symmetry at adult stage and bilateral in the larval stage.

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'X' indicates absence
'+' indicates presence

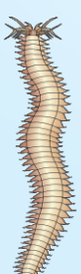
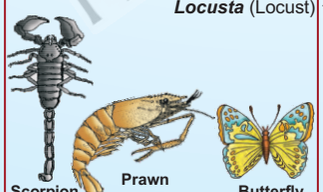
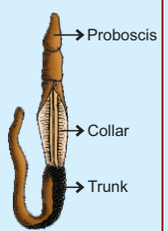
3 COMPARATIVE ACCOUNT FROM PORIFERA TO ASCHELMINTHES

Parameters	Porifera (Sponges)	Coelenterata (Cnidaria)	Ctenophora (Sea walnuts)	Platyhelminthes (Flatworms)	Aschelminthes (Round worms)
Habitat/Habit	Mostly marine, some are fresh water (*Spongilla*)	Mostly marine, some are fresh water (*Hydra*), sessile or free swimming	Exclusively marine	Free living or parasitic	Aquatic, terrestrial, parasitic in plants and animals
Exoskeleton	X	Coral forms have skeleton of $CaCO_3$	X	X	X
Endoskeleton	Spicules/spongin fibres	X	X	X	X
Digestive system/ Digestion	❍ Digestive system absent ❍ **Intracellular digestion**	❍ Digestive system **incomplete** ❍ Mouth on hypostome leading to body cavity **Gastro-vascular cavity** ❍ **Intra and extracellular digestion**	❍ Extracellular and intracellular digestion	❍ Digestive system **incomplete with single opening** ❍ **Extracellular digestion** ❍ Some forms absorb food directly from body surface	❍ Complete alimentary canal with **muscular pharynx** ❍ Extracellular digestion
Respiratory structure	Cell surface	Body wall		Free living-body surface	Free living-body surface
Circulatory system	Circulating fluid = water				
Excretory system/ Surface	Body surface			**Flame cells** (Protonephridia) for excretion and osmoregulation	Excretory tube opens out through **excretory pore**
Nervous system	X	**Neurons appear**	+	+	+
Asexual reproduction	Fragmentation, gemmule formation	Budding	X	High regeneration-*Planaria* capacity	X
Sexual reproduction	❍ Present ❍ Hermaphrodites	Present	❍ Present ❍ Hermaphrodites	❍ Present ❍ Hermaphrodites	**Distinctly dioecious**
Fertilization	Internal	External		Internal	
Development	Indirect, **larva morphologically distinct from adult**	Indirect/direct	Indirect	Indirect through many larval stages	Indirect/direct (young one resembles adult)
Unique features and examples	❍ **Water canal system** → **Functions** → Food gathering, Respiratory exchange, Removal of wastes ❍ **Choanocytes**/collar cells line the **spongocoel** (central cavity). **Examples:** *Euspongia* (Bath sponge), *Spongilla* (Fresh water sponge), *Sycon* (Scypha)	❍ Name derived from cnidoblasts/ cnidocytes containg **nematocysts**, present on body and tentacles. **Functions** → Anchorage, Defense, Capture of prey ❍ ***Obelia* exhibits 2 basic forms:** Polyp (Sessile, Cylindrical) ⇄ Alternation of generation/ Metagenesis (Asexually / Sexually) ⇄ Medusa (Free swimming, Umbrella like) **Examples:** ***Physalia*** (Portuguese man-of-war), ***Pennatula*** (Sea-pen), ***Gorgonia*** (Sea-fan), ***Meandrina*** (Brain coral) *Adamsia* (Sea anemone), *Aurelia* (Jelly fish)	❍ **8 external rows of comb plates** for locomotion, hence, called **comb jellies** ❍ **Exhibit Bioluminescence** *i.e.*, property to emit light **Examples:** ***Ctenoplana***, ***Pleurobrachia***	❍ **Dorsoventrally** flattened body ❍ Hooks and suckers present in parasitic forms ❍ **1st ones with bilateral symmetry** **Examples:** *Taenia* (Tapeworm), *Fasciola* (Liver fluke)	❍ Circular in **cross-section** ❍ **1st ones with complete alimentary canal** ❍ **Females longer than male** ❍ **Posterior end curved in males** **Examples:** ***Wuchereria*** (Filaria worm), ***Ancylostoma*** (Hookworm), ***Ascaris*** (Round worm) Male, Female

Parameters	Ostia	Osculum
❍ Number	Many	Usually one
❍ Location	Body surface	Body surface
❍ Size	Minute	Large
❍ Water flow	Entry	Exit

4 COMPARATIVE ACCOUNT FROM ANNELIDA TO HEMICHORDATA

- **All have complete alimentary canal with extracellular digestion**
- **All can reproduce sexually and are usually oviparous**

Parameters	Annelida (Segmented worms)	Arthropoda(Joint appendages) Largest Phylum	Mollusca/Soft bodied Second Largest Phylum	Echinodermata (Spiny skinned)	Hemichordata (Half chordates)
Habitat	Aquatic and Terrestrial			Exclusively marine	
Body divisions/ appearance	Distinct segments metameres/annuli	Head, thorax, abdomen	Head, muscular foot visceral hump	Star like	Proboscis, collar, trunk (worm like)
Locomotory structure	○ Longitudinal and circular muscles ○ Parapodia/lateral appendages in some	Joined appendages	Muscular foot	**Water vascular system**	X
Exoskeleton	X	Chitinous/Cuticle	Calcareous shells	Spines	X
Digestive system	+	+	Mouth with file like rasping organ, **radula** for feeding	**Mouth**-lower side/ventral **Anus**-upper side/dorsal	+
Respiratory system/ surface	Body surface	Gills, book gills, tracheal system, book lungs	Feather like gills in mantle cavity	Water vascular system	Gills
Circulatory system	Closed	Open			
Excretory system	Nephridia	Malpighian tubules	Gills	X	Proboscis gland
Nervous system	Paired ganglia with double ventral nerve cord		+	+	+
Sense organs	Eyes, Tentacles	Eyes (simple, compound), Antennae, Statocyst (balancing)	Tentacles	+	+
Mono/Dioecious	**Monoecious** – Earthworm, Leech **Dioecious** – *Nereis* (aquatic form)	Mostly dioecious	Usually dioecious	Dioecious	
Fertilization	External/internal	Usually internal	External	Usually external	External
Development	Direct/Indirect		Indirect	Indirect with free swimming larva	Indirect
Unique features and Examples	○ **1st ones with metameric segmentation and true coelom** **Examples:** ***Pheretima*** (Earthworm)  ***Nereis*** ***Hirudinaria*** (Blood sucking leech)	**Examples:** ○ Economically important insects - ***Apis*** (Honey bee), ***Bombyx*** (Silkworm), ***Laccifer*** (Lac insect) ○ Vectors - ***Anopheles***, ***Culex***, ***Aedes*** (Mosquitoes) ○ Living fossil - ***Limulus*** (King crab) ○ Gregarious pest - ***Locusta*** (Locust)  Scorpion Prawn Butterfly	○ Soft and spongy layer of skin forms a **mantle** over the **visceral hump**. ○ Space between hump and mantle is **mantle cavity**. **Examples:** ***Sepia*** (Cuttlefish), ***Loligo*** (Squid), ***Pinctada*** (Pearl oyster), ***Dentalium*** (Tusk shell), ***Chaetopleura*** (Chiton), ***Aplysia*** (Seahare) ***Pila*** (Apple snail) ***Octopus*** (Devil fish)	○ **Water vascular system** that helps in – Locomotion, Capture and transport of food, Respiration ○ Presence of **Calcareous ossicles** **Examples:** ***Cucumaria*** (Sea cucumber), ***Echinus*** (Sea urchin), ***Antedon*** (Sea lily) ***Asterias*** (Star fish) ***Ophiura*** (Brittle star)	○ Presence of **rudimentary stomochord** ○ Earlier considered as subphylum under phylum Chordata but now placed as separate phylum under non-chordata **Examples:** ***Saccoglossus***  Proboscis Collar Trunk ***Balanoglossus***

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Sharpen Your Understanding

1. All of the following are basis of classification of animals **except** [NCERT Pg. 46]
   (1) Number of cells
   (2) Body symmetry
   (3) Nature of coelom
   (4) Arrangement of cells
2. Organ level of organisation is present in the members of which phylum? [NCERT Pg. 46]
   (1) Cnidaria (2) Ctenophora
   (3) Platyhelminthes (4) Porifera
3. What is **true** for open circulatory system? [NCERT Pg. 47]
   (1) Cells and tissues are directly bathed in blood
   (2) Capillaries are present
   (3) Blood is circulated only through a series of vessels of varying diameter
   (4) Present in earthworm
4. Digestive system in phylum Platyhelminthes [NCERT Pg. 47]
   (1) Has two openings to the outside of the body
   (2) Has one opening to the outside of the body
   (3) Is absent in most of the members
   (4) Opens through excretory pore to the outside of the body
5. When any longitudinal plane passing through the central axis of the body divides the organism into two identical halves, it is called [NCERT Pg. 47]
   (1) Bilateral symmetry
   (2) Radial symmetry
   (3) Asymmetry
   (4) Biradial symmetry
6. Choose the **odd** one w.r.t. coelenterates [NCERT Pg. 47]
   (1) Ectoderm (2) Endoderm
   (3) Mesoderm (4) Mesoglea
7. Triploblastic acoelomate animals belong to which phylum? [NCERT Pg. 48]
   (1) Ctenophora (2) Platyhelminthes
   (3) Aschelminthes (4) Annelida
8. Presence of truly coelomate animals ranges from phylum [NCERT Pg. 48]
   (1) Aschelminthes to Chordata
   (2) Annelida to Chordata
   (3) Platyhelminthes to Chordata
   (4) Ctenophora to Chordata
9. Metameric segmentation is present in [NCERT Pg. 52]
   (1) *Pheretima* (2) *Ascaris*
   (3) *Balanoglossus* (4) *Pila*

NCERT Based MCQs

10. Which of the following is **incorrect** w.r.t. notochord? [NCERT Pg. 48]
    (1) Ectodermally derived
    (2) Rod-like structure
    (3) Present on the dorsal side
    (4) Absent in animals ranging from phylum Porifera to Echinodermata
11. Select the **correct** option w.r.t. sponges [NCERT Pg. 49]
    (1) All are marine
    (2) All are asymmetrical
    (3) Collar cells line spongocoel only
    (4) Usually monoecious
12. Choose the **correct** match w.r.t. excretory structure [NCERT Pg. 51-54]
    (1) *Fasciola* – Excretory tube
    (2) *Ancylostoma* – Flame cells
    (3) *Laccifer* – Malpighian tubules
    (4) *Chaetopleura* – Proboscis gland
13. Select the **incorrect** match w.r.t. fertilisation [NCERT Pg. 49-54]
    (1) Sponges – Internal
    (2) Ctenophores – External
    (3) Roundworms – Internal
    (4) Echinoderms – Internal

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14. All are **correct** w.r.t. respiratory organ of animal shown below, **except**

[NCERT Pg. 53]

(1) Feather like gills
(2) Present in visceral hump
(3) Help in respiration and excretion
(4) Present in the members of second largest phylum

15. Match column-I with column-II and choose the **correct** option [NCERT Pg. 49-54]

Column-I	Column-II
a. *Asterias*	(i) Jointed appendages
b. *Sycon*	(ii) Canal system
c. *Apis*	(iii) Excretory system is absent
d. *Nereis*	(iv) Parapodia

(1) a(iii), b(ii), c(i), d(iv)
(2) a(ii), b(iii), c(iv), d(i)
(3) a(i), b(ii), c(iii), d(iv)
(4) a(iv), b(iii), c(ii), d(i)

16. Sexes are separate in [NCERT Pg. 52]

(1) *Pleurobrachia* (2) *Nereis*
(3) *Taenia* (4) *Hirudinaria*

17. Development may be **direct or indirect** in the members of which phylum? [NCERT Pg. 49-52]

(1) Porifera
(2) Ctenophora
(3) Platyhelminthes
(4) Aschelminthes

18. All are the functions of water vascular systemin echinoderms **except** [NCERT Pg. 54]

(1) Locomotion
(2) Reproduction
(3) Respiration
(4) Capture and transport of food

19. Match column-I with column-II and choose the **correct** match. [NCERT Pg. 49-54]

Column-I	Column-II
a. *Euspongia*	(i) Calcareous shell
b. Corals	(ii) Exoskeleton of calcium carbonate
c. *Pinctada*	(iii) Spongin fibres
d. *Echinus*	(iv) Calcareous endoskeleton

(1) a(iii), b(iv), c(i), d(ii)
(2) a(iii), b(ii), c(i), d(iv)
(3) a(iv), b(iii), c(ii), d(i)
(4) a(i), b(ii), c(iii), d(iv)

20. In most of the members of largest phylum, the body consists of [NCERT Pg. 53-54]

(1) Head, muscular foot and visceral hump
(2) Head, thorax and abdomen
(3) Proboscis, collar and trunk
(4) Cephalothorax and abdomen

Thinking in Context

1. _____ members of Animalia are multicellular. [NCERT Pg. 46]

2. When body of an organism can be divided into identical left and right halves by only one longitudinal plane, it is called _____ symmetry. [NCERT Pg. 47]

3. Animals in which the cells are arranged in two embryonic layers an external _____ and an internal _____, are called _____ animals. [NCERT Pg. 47]

4. The body cavity which is not lined by mesoderm, instead, the mesoderm is present as scattered pouches, is called _____. [NCERT Pg. 48]

5. The animals in which body cavity is absent are called _____. [NCERT Pg. 48]

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6. When body is _____ and _____ divided into segments with a serial _____ of at least some organs is called metameric segmentation. [NCERT Pg. 48]

7. Canal system of sponges helps in _____, _____ and _____. [NCERT Pg. 49]

8. In sponges, water enters through minute pores called _____ into a central cavity called _____, from where it goes out through _____. [NCERT Pg. 49]

9. In metagenesis, polyps produce medusae _____ and medusae form polyps _____. [NCERT Pg. 50]

10. The name Cnidaria is derived from the _____ present on the _____ and the _____. [NCERT Pg. 50]

11. In ctenophores, body bears _____ external rows of _____ which help in _____. [NCERT Pg. 51]

12. Some Platyhelminths absorb nutrients from the host directly through their _____. [NCERT Pg. 51]

13. Aschelminths are parasites in _____ and _____. [NCERT Pg. 52]

14. In roundworms, alimentary canal is complete with a well developed _____. [NCERT Pg. 52]

15. Annelids possess _____ and _____ muscles which help in _____. [NCERT Pg. 52]

❑ ❑ ❑

16. *Nereis* possesses lateral appendages, _____ which help in _____. [NCERT Pg. 52]

17. The body of arthropods is covered by _____. [NCERT Pg. 53]

18. In cuttle fish, mantle cavity is the space between _____ and _____. [NCERT Pg. 53]

19. In molluscs, _____ contains a file like rasping organ for _____, called _____. [NCERT Pg. 53]

20. Adult echinoderms are _____ symmetrical but larvae are _____ symmetrical. [NCERT Pg. 54]

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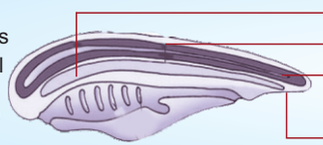
Animal Kingdom: Chordates

1B
Chapter

1 PHYLUM-CHORDATA

General Features :

- Triploblastic organisms
- Bilaterally symmetrical
- Coelomates
- Organ-system level of organisation
- Closed circulatory system



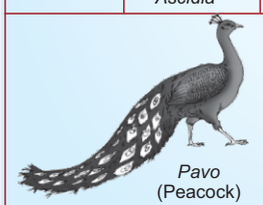
Basic plan of a chordate

Salient features	Chordates	Non-chordates
Notochord	✓	×
Central nervous system	Dorsal, hollow and single	Ventral, solid and double
Paired pharyngeal gill slits	✓	×
Post anal tail	✓	×
Position of heart	Ventral	Dorsal (if present)

2 CLASSIFICATION OF CHORDATES

Sub-phyla

Parameters	Urochordata/ Tunicata	Cephalochordata	Vertebrata
	Protochordates		
Habitat	Exclusively marine		Variety of habitats - Polar ice caps, deserts, mountains, forests, grasslands and dark caves
Notochord	Only in larval tail	Extends from head to tail and persists throughout their life	Present in embryonic stage and is replaced by cartilaginous or bony vertebral column in the adult
Examples	*Salpa*, *Doliolum* *Ascidia*	*Branchiostoma* (Amphioxus or Lancelet)	*Scoliodon* (Dog fish), *Rana* (Frog), *Crocodilus* (Crocodile), *Pavo* (Peacock), *Canis* (Dog)



Pavo (Peacock)

Neophron (Vulture)

Chelone (Turtle)

Chameleon (Tree lizard)

All vertebrates are chordates but all chordates are not vertebrates.

3 CLASSIFICATION OF VERTEBRATES

Division

Parameters	Agnatha	Gnathostomata
Jaws	Absent	Present
Fins/limbs	Unpaired fins	Paired fins or limbs
Sexes are separate	–	✓

Gnathostomata → Super class

- **Pisces** • Bear fins → Class: Chondrichthyes & Osteichthyes
- **Tetrapoda** • Bear two pairs of limbs → Class: Amphibia, Reptilia, Aves, Mammalia

Agnatha → Class: Cyclostomata

4 CYCLOSTOMATA

Parameters	
Habitat	Marine
Habit	Ectoparasite on fishes
Temperature regulation	No **(Poikilothermous)**
Exoskeleton	Scales are absent
Endoskeleton	Cartilaginous cranium and vertebral column
Appendages	**Unpaired fins**
Digestive system	Circular and sucking mouth without jaws
Respiratory system	6-15 pairs of gill slits
Circulatory system	Closed type
Excretory system	Kidneys
Reproductive system	○ Migrate to fresh water for spawning ○ After spawning, the adult dies within few days
Development	○ Indirect Larvae return to ocean after metamorphosis
Examples	*Myxine* (Hag fish), *Petromyzon* (Lamprey)

Petromyzon (Lamprey)

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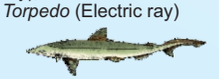
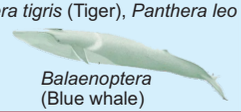
5 COMPARATIVE ACCOUNT OF GNATHOSTOMATES

Characteristics	Chondrichthyes	Osteichthyes	Amphibia	Reptilia	Aves	Mammalia
Habitat	Marine	Both marine and fresh water	Both on land and in water	Mostly terrestrial		Terrestrial, aquatic
Habit	Predaceous	–	Dual life	Creeping and crawling	Most of them can fly except flightless birds	Limbs adapted to fly and live in water
Temperature regulation	**Poikilothermous** (Cold blooded)				**Homeothermous** (Warm blooded)	
Exoskeleton	**Placoid scales** for tough skin	**Cycloid** and **ctenoid** scales	❍ Scales are absent ❍ Skin is moist	Epidermal scales or scutes with dry cornified skin	❍ Scales on hindlimbs ❍ Body covered by feathers and skin is dry	Skin may possess hair
Endoskeleton	Cartilaginous	Bony			Bony (Fully ossified) **Pneumatic bones**	Bony
Digestive system	❍ Ventral mouth ❍ Teeth are modified scales & backwardly directed ❍ Powerful jaws	Terminal mouth	Cloaca present	–	❍ Additional gizzard and crop ❍ Beak present	Different types of teeth in the jaws
Respiratory system	Gill slits **without operculum**	4 pairs of gill slits **with operculum**	Gills, skin and lungs	Lungs	❍ Lungs, ❍ **Air sacs** supplement respiration	Lungs
Circulatory system	2 chambered heart with 1 auricle and 1 ventricle		3 chambered heart with 2 auricles and 1 ventricle	3 chambered heart with 2 auricles and 1 ventricle **except crocodile (4 chambered heart)**	4 chambered heart with 2 auricles and 2 ventricles	
Excretory system	Kidneys (Excretion and Osmoregulation)					
Sense organs ❍ **Eye**	Eyes present		Eyes with eyelids			
❍ **Ear**	Tympanum absent		Tympanum represents ear	Tympanum represents ear & many reptiles do not have external ear opening	Tympanum represents ear, many birds have external ear opening	**External ear/pinna present**
Fertilisation	Internal as **pelvic fins** of males bear **claspers**	Usually external	External	Internal		
Oviparous/ Viviparous	Many are viviparous	Mostly oviparous	Oviparous			Viviparous **except** egg laying **Platypus**
Development	Direct		Indirect	Direct		
Unique features	❍ Streamlined body ❍ Notochord persists throughout life ❍ **Absence of air bladder,** hence, swim continuously to avoid sinking **Examples :** *Carcharodon* (Great white shark), *Trygon* (Poisonous sting ray), *Torpedo* (Electric ray)  *Scoliodon* (Dog fish) *Pristis* (Saw fish)	❍ Streamlined body ❍ They have air bladder/ swim bladder that regulated **buoyancy** **Examples :** **Marine** – *Exocoetus* (Flying fish), *Hippocampus* (Sea horse) **Fresh water** – *Labeo* (Rohu), *Clarias* (Magur); Aquarium – *Betta* (Fighting fish), *Pterophyllum* (Angel fish). *Catla* (Katla),	❍ Body divided into head and trunk, tail in some e.g. Salamander ❍ Alimentary canal, urinary and reproductive tracts open into a common chamber called **cloaca** **Examples :** *Bufo* (Toad), *Hyla* (Tree frog) *Ichthyophis* (Limbless amphibia) *Rana* (Frog) *Salamandra* (Salamander)	Snakes and lizards shed their scales as **skin cast** **Examples :** *Chelone* (Turtle), *Testudo* (Tortoise), *Calotes* (Garden lizard), *Alligator* (Alligator). *Hemidactylus* (Wall lizard), **Poisonous snakes** – *Bangarus* (Krait), *Vipera* (Viper) *Crocodilus* (Crocodile) *Naja* (Cobra)	❍ Forelimbs modified into wings ❍ Hindlimbs of birds are modified for walking, swimming or clasping the tree branches ❍ Skin is dry without glands **except oil gland** at the base of tail **Examples :** **Flying birds** *Corvus* (Crow), *Columba* (Pigeon) **Flightless birds** *Aptenodytes* (Penguin) *Psittacula* (Parrot) *Struthio* (Ostrich)	❍ Presence of **mammary glands** to nourish young ones **Examples :** **Oviparous** *Ornithorhynchus* (Platypus) **Viviparous** *Macropus* (Kangaroo), *Pteropus* (Flying fox), *Camelus* (Camel), *Macaca* (Monkey), *Rattus* (Rat), *Canis* (Dog), *Felis* (Cat), Elephas (Elephant), *Equus* (Horse) *Delphinus* (Common dolphin), *Panthera tigris* (Tiger), *Panthera leo* (Lion).  *Balaenoptera* (Blue whale)

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Sharpen Your Understanding

1. Chordates are characterised by the presence of [NCERT Pg. 54]
   (1) Double, ventral, solid nerve cord
   (2) Notochord
   (3) Dorsal heart
   (4) Only organ level of organisation
2. Select the **correct** statement w.r.t. notochord in urochordates. [NCERT Pg. 55]
   (1) Present in larval tail only
   (2) Extends from head to tail in adults
   (3) Persists throughout the life of organism
   (4) Replaced by vertebral column
3. Chordates differ from non-chordates in all **except** [NCERT Pg. 55]
   (1) Presence of paired pharyngeal gill slits
   (2) Position of heart
   (3) Presence of post anal tail
   (4) Presence of three germ layers
4. All chordates are **not** vertebrates because [NCERT Pg. 47]
   (1) Notochord is not replaced by a cartilaginous or bony vertebral column in protochordates
   (2) Notochord is present in all vertebrates throughout life
   (3) Ventral muscular heart is present
   (4) Kidneys are present for excretion and osmoregulation

NCERT Based MCQs

5. Which of the following is **not** a feature of vertebrates? [NCERT Pg. 55]
   (1) Ventral muscular heart
   (2) Kidneys for osmoregulation
   (3) Paired fins or limbs
   (4) Dorsal, single, solid nerve cord
6. Select the **incorrect** statement w.r.t. chordates. [NCERT Pg. 55]
   (1) Notochord is dorsal to nerve cord
   (2) Notochord is dorsal to gut
   (3) Nerve cord is dorsal to gut
   (4) Nerve cord is dorsal, single and hollow
7. Poikilotherms with internal fertilization, oviparity and direct development are all, **except** [NCERT Pg. 55]
   (1) *Ascidia*
   (2) *Aligator*
   (3) *Hemidactylus*
   (4) *Chameleon*
8. How many among following are able to maintain constant body temperature and can fly? [NCERT Pg. 58]

   Pteropus, Neophron, Columba, Struthio, Pavo, Macaca

   (1) One (2) Three
   (3) Two (4) Four
9. Select the mismatch w.r.t. scientific name in column I and common name in column II. [NCERT Pg. 55]

	Column I	Column II
(1)	*Clarias*	Magur
(2)	Dog	*Canis*
(3)	*Calotes*	Garden lizard
(4)	*Corvus*	Crow

10. Which of the following is a jawless vertebrate? [NCERT Pg. 56]
    (1) *Petromyzon*
    (2) *Scolidon*
    (3) *Calotes*
    (4) *Macropus*
11. Choose the **odd** one w.r.t. cyclostomes. [NCERT Pg. 56]
    (1) Sucking and circular mouth
    (2) Absence of jaws
    (3) Scales are absent
    (4) Presence of paired fins
12. In chondrichthyes, scales are [NCERT Pg. 56]
    (1) Cycloid
    (2) Ctenoid
    (3) Placoid
    (4) Ganoid

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13. Chondrichthyes differ from Osteichthyes in possessing [NCERT Pg. 57]
(1) Bony endoskeleton (2) Air bladder
(3) Claspers (4) Operculum

14. Cloaca is present in [NCERT Pg. 57]
(1) *Rana, Ichthyophis*
(2) *Pteropus, Felis*
(3) *Labeo, Exocoetus*
(4) *Camelus, Delphinus*

15. Which of the following animal is a homeotherm and is oviparous? [NCERT Pg. 58]
(1) *Aptenodytes*
(2) *Elephas*
(3) *Pristis*
(4) *Exocoetus*

16. Choose the **mismatch**. [NCERT Pg. 60]

(1)	*Columba*	–	Pneumatic bones
(2)	*Equus*	–	Similar types of teeth
(3)	*Crocodilus*	–	Scutes
(4)	*Neophron*	–	Air sacs connected to lungs

17. Select the **odd** one w.r.t. external fertilization. [NCERT Pg. 57]
(1) *Carcharodon*
(2) *Betta*
(3) *Bufo*
(4) *Pterophyllum*

18. Which of the following is **incorrect** w.r.t. Aves? [NCERT Pg. 58]
(1) Forelimbs have scales
(2) Crop and gizzard are the additional chambers in the digestive tract
(3) Endoskeleton is fully ossified
(4) Air sacs supplement respiration

19. Exclusive characters of members of class mammalia are all of the following **except** [NCERT Pg. 60]
(1) Mammary glands
(2) Hair
(3) Pulmonary respiration
(4) Ear pinnae

20. Four-chambered heart and epidermal scales on body are present in [NCERT Pg. 58]
(1) *Bufo* (2) *Pristis*
(3) *Crocodilus* (4) *Canis*

Thinking in Context

1. Protochordates inhabit _____ water exclusively [NCERT Pg. 55]

2. Subphyla _____ and _____ are often referred as protochordates. [NCERT Pg. 55]

3. Cyclostomes have an elongated body bearing _____ pairs of gill slits. [NCERT Pg. 56]

4. Cyclostomes are _____ but migrate for spawning to_____ [NCERT Pg. 56]

5. After spawning, within a few days, adult cyclostomes _____. Their larvae, _____, return to the ocean. [NCERT Pg. 56]

6. In Chondrichythyes, mouth is located _____ and in bony fishes, it is mostly _____ in position. [NCERT Pg. 56]

7. _____ are modified placoid scales in cartilaginous fishes and are _____ directed. [NCERT Pg. 56]

8. Electric organ is present in _____ and poison sting is present in _____ [NCERT Pg. 57]

9. Due to the absence of air bladder, _____ fishes have to swim constantly to avoid sinking. [NCERT Pg. 56]

10. In amphibians, body is divisible into _____ and _____. _____ may be present in some. [NCERT Pg. 57]

11. _____, _____ and _____ opens into a common chamber called cloaca. [NCERT Pg. 57]

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12. In amphibians, respiration occurs through _____, _____ and _____. [NCERT Pg. 57]
13. In reptiles, body is covered by _____ and _____ skin, _____ scales or _____. [NCERT Pg. 58]
14. Snakes and lizards shed their scales as _____ [NCERT Pg. 58]
15. In Aves, skin is dry without glands except the _____ at the base of the _____ [NCERT Pg. 58]
16. The characteristic feature of Aves are the presence of _____ [NCERT Pg. 58]
17. In Aves, jaws are modified into _____ and forelimbs are modified into _____ [NCERT Pg. 58]
18. The skin of mammals is unique in possessing _____ [NCERT Pg. 60]
19. The digestive tract of birds has additional chambers, the _____ and _____ [NCERT Pg. 58]
20. In Aves, air sacs connected to lungs _____ respiration. [NCERT Pg. 59]

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Structural Organisation in Animals: Animal Tissues

2A Chapter

1 TISSUE

- A group of similar cells along with intercellular substances which perform a specific function.
- **Organs** such as stomach, lungs, heart and kidney comprise specific proportion and pattern of **all basic types of tissues**.
- **Division of labour** contributes to survival of multicellular organisms e.g., *Hydra*.

2 TYPES OF TISSUES

Based on
- Structure of cells
- Function performed by cells

→ Epithelial tissue
→ Connective tissue
→ Muscular tissue
→ Neural tissue

4 CELL JUNCTIONS

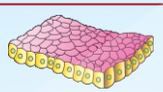
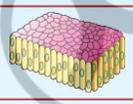
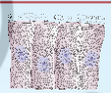
Tight junctions
- **Prevent leakage** across a tissue

Adhering junctions
- Perform **cementing** to keep neighbouring cells together

Gap junctions
- Facilitate the cells to **communicate** with each other by connecting the cytoplasm of adjoining cells, for rapid transfer of ions, small molecules and sometimes big molecules.

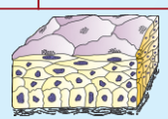
3 EPITHELIAL TISSUE

Simple epithelium (single-layered)

Characteristics	Squamous	Cuboidal	Columnar	Ciliated	Glandular
Figure					
Cells	Flattened, irregular boundaries	Cube-like	Tall and slender	Cuboidal or columnar	Cuboidal or columnar
Nucleus	Central	Central	At base	Central or at base	Central or at base
Function	Diffusion boundary	Secretion and absorption	Secretion and absorption	Move particles or mucus in a specific direction	Specialised for secretion
Location	Air sacs of lungs, walls of blood vessels	Tubular parts of nephron (PCT), ducts of glands	Stomach and intestine	Bronchioles and fallopian tubes	Salivary glands

Compound epithelium (multi-layered)

Layers	2 or more cell layers
Function	○ Protection against mechanical and chemical stresses ○ Limited role in secretion and absorption
Location	Dry surface of skin, buccal cavity, pharynx, inner lining of ducts of salivary glands and pancreas

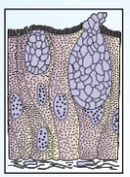


- **Microvilli** present in PCT and small intestine increase surface area for absorption.
- Epithelial tissue provides a covering or a lining for some part of the body.
- Free surface of this tissue faces body fluid or outside environment.
- Its cells are compactly packed with little intercellular matrix.

Types of glands:

I. Based on the number of cells

Number of cells	Single → Unicellular	Many → Multi-cellular
Example	Goblet cells (Secrete mucus)	Salivary glands (Secrete saliva)



II. Based on the mode of pouring their secretions

	Exocrine glands	Endocrine glands
Ducts	Present	Absent
Secretions	Mucus, saliva, earwax, oil, milk, digestive enzymes and other cell products	Hormones

- Endocrine glands directly release their secretions into the fluid bathing the gland

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5 CONNECTIVE TISSUE

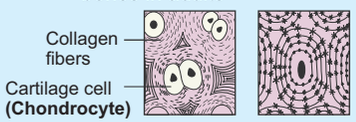
- Most abundant and widely distributed tissue
- Links and supports other tissues and organs
- **Components of Connective tissue:**
  - **Matrix/ground substance :** Modified polysaccharides **or Intercellular material**
  - **Cells:** Fibroblasts, macrophages, adipocytes etc.
  - **Fibres:** Fibroblasts secrete collagen or elastin fibres

Fibres provide strength, elasticity and flexibility to the tissue

III. SPECIALISED CONNECTIVE TISSUE

1. Skeletal Connective Tissues

	Cartilage	Bones
Matrix	Solid, pliable	Hard and non-pliable
Cells in lacuna	Chondrocytes	Osteocytes
Location/ Functions	Tip of nose, outer ear joints, between vertebrae, limbs and hands in adults Most of the cartilages in vertebrate embryos are replaced by bones in adults	Constitutes main structural framework; Interact with skeletal muscles to bring movements; **Bone marrow** in some bones is the site of production of blood cells.



2. Fluid Connective Tissue

- Blood – main circulating fluid that helps in the transport of various substances
- Composed of plasma, RBC, WBC, platelets
- Fibroblasts and fibres are absent in blood.

- Cartilage resists compression.
- Calcium salts and collagen fibres in ground substance provide strength to the bones.
- Lacunae are small cavities enclosing cells with in matrix secreted by them.

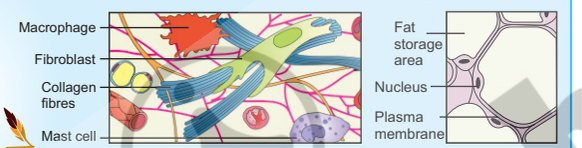
6 THREE TYPES OF CONNECTIVE TISSUE

I. LOOSE CONNECTIVE TISSUE

- Cells and fibres are loosely packed in semi solid matrix

Types

	Areolar tissue	Adipose tissue
Major cells	Fibroblasts, macrophages, mast cells	Adipocytes
Function(s)	Serve as support framework for epithelium	Reservoir of stored fats
Location	Beneath skin	Mainly beneath skin



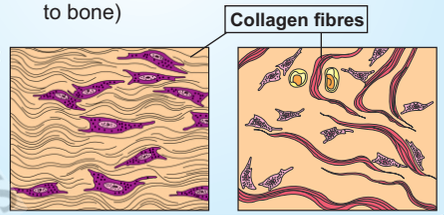
- Excess of nutrients not meant for immediate use are converted to fats and are stored in adipose tissue

II. DENSE CONNECTIVE TISSUE

- Fibroblasts and fibres are compactly packed in matrix

Types

	Dense regular	Dense irregular
Cells and fibres	Parallel bundles of collagen fibres	Fibroblasts and fibres are oriented differently
Location	**Tendons** (attach skeletal muscles to bone) **Ligaments** (attach bone to bone)	Skin
Arrangement of fibres and cells		



7 MUSCULAR TISSUE

- $(\text{Myofibrils})_n \rightarrow (\text{Muscle fibres})_n \rightarrow$ Muscle
- Show **contractility** and return to their uncontracted state in a coordinated fashion
- Play an active role in all movements

Parameters	Skeletal muscle fibres	Smooth/Visceral muscle fibres	Cardiac muscle fibres
Shape	Cylindrical	Spindle/fusiform	Cylindrical
No. of nuclei	Multi-nucleated	Uninucleated	Uninucleated
Location of nuclei	Peripheral nuclei	Central	Central
Striations	Striated	Non striated	Faint striations
Branching	Unbranched	Unbranched	Branched
Under control of will	Yes (Voluntary)	No (Involuntary)	No (Involuntary)
Junctions	Absent	Present	Present
Location	Attached to bones *e.g.* Biceps	Blood vessels, stomach, intestine	Heart wall

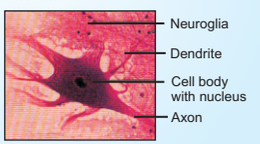
- **Communication junctions (intercalated discs)** at some fusion points allow the cells of cardiac muscles to contract as a unit.

8 NEURAL TISSUE

- Tissue with greatest control over the body's responsiveness to changing conditions.

Tissue Components

	Neurons	Neuroglial cells
	Unit of neural system	More than one half the volume of neural tissue
Excitability	✓	✗
Function	Respond to changing conditions through various stimuli	Protect and support neurons



- Upon suitable stimulation, the electrical disturbance generated travels swiftly along the plasma membrane of neuron.

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Sharpen Your Understanding

1. Simple epithelium is present in all the following regions **except** [NCERT Pg. 101 and 102]
   (1) Stomach (2) Fallopian tube
   (3) Air sacs of lung (4) Skin
2. In which tissue, are cells compactly packed with little intercellular matrix? [NCERT Pg. 101]
   (1) Epithelial tissue
   (2) Muscular tissue
   (3) Neural tissue
   (4) Connective tissue
3. Select the single layered epithelium in which cells are tall, slender and nuclei are present at the base [NCERT Pg. 101]
   (1) Squamous epithelium
   (2) Cuboidal epithelium
   (3) Columnar epithelium
   (4) Compound epithelium
4. Single layer of cube-like cells having microvilli on their free surface are present in [NCERT Pg. 101]
   (1) Ducts of glands (2) PCT of nephron
   (3) Bronchioles (4) Fallopian tubes
5. The epithelium, made up of a single layer of flattened cells with irregular boundaries is present in [NCERT Pg. 101]
   (1) Walls of blood vessels
   (2) Pharynx
   (3) Buccal cavity
   (4) Skin
6. Finger like projections of epithelial cells which increase surface area for absorption are present in [NCERT Pg. 101]
   (1) Stomach (2) Small intestine
   (3) Bronchioles (4) Fallopian tubes
7. Which of the following is **not** the secretion of exocrine glands? [NCERT Pg. 102]
   (1) Mucus
   (2) Milk
   (3) Ear wax
   (4) Hormones
8. Epithelium responsible for providing protection against mechanical and chemical stresses is absent in [NCERT Pg. 102]
   (1) Pancreatic ducts
   (2) Ducts of salivary glands
   (3) Buccal cavity
   (4) Tubular parts of nephron
9. Cell junctions in epithelial tissue that perform cementing to keep neighbouring cells together are [NCERT Pg. 102]
   (1) Tight junctions
   (2) Adhering junctions
   (3) Gap junctions
   (4) Communication junctions

NCERT Based MCQs

10. Which is the most abundant and widely distributed tissue in the body? [NCERT Pg. 102]
    (1) Epithelial tissue
    (2) Connective tissue
    (3) Muscular tissue
    (4) Neural tissue
11. Tendons join [NCERT Pg. 103]
    (1) Skeletal muscle to bone
    (2) Bone to bone
    (3) Smooth muscles to bone
    (4) Striated muscle to non striated muscle
12. Dense irregular connective tissue is present in [NCERT Pg. 103]
    (1) Tendon
    (2) Ligament
    (3) Skin
    (4) Cartilage
13. Fibres are absent in [NCERT Pg. 103]
    (1) Areolar tissue
    (2) Blood
    (3) Bones
    (4) Tendons
14. Cartilage is present in all the given regions **except** [NCERT Pg. 104]
    (1) Outer ear joints
    (2) Tip of nose
    (3) Between vertebrae
    (4) Ligaments

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15. Biceps is a type of _____.
Select the option that fills the blank **correctly**. [NCERT Pg. 104]
(1) Skeletal muscle
(2) Smooth muscle
(3) Cardiac muscle
(4) Non-striated muscle

16. Choose the **odd** one w.r.t. location of non-striated, involuntary muscle.
[NCERT Pg. 105]
(1) Wall of blood vessels
(2) Stomach
(3) Intestine
(4) Heart

17. Select the involuntary muscle in which both adhering junction and intercalated discs are present [NCERT Pg. 105]
(1) Skeletal muscle
(2) Smooth muscle
(3) Non-striated muscle
(4) Cardiac muscle

18. Which of the following statement is **incorrect** w.r.t. neural tissue?
[NCERT Pg. 105]
(1) All cells are excitable in this tissue
(2) This tissue exerts greatest control over the body's responsiveness
(3) Neuroglial cells protect and support neurons
(4) Neurons are unit of neural system

19. Read the following statements and select the **incorrect** statement w.r.t. given muscle fibres [NCERT Pg. 105]
(1) Smooth muscle fibres taper at both ends
(2) Cell junctions hold smooth muscle fibres together
(3) Smooth muscle fibres are bundled together in a connective tissue sheath
(4) Cardiac muscle fibres are unbranched

20. Select the tissue having hard, non pliable ground substance. [NCERT Pg.104]
(1) Enamel
(2) Bone
(3) Cartilage
(4) Ligament

Thinking in Context

1. The structure of the cells vary according to their _____. [NCERT Pg. 100]
2. Function of _____ is to move particles or mucus in a specific direction over the epithelium. [NCERT Pg. 101]
3. _____ cells of the alimentary canal are example of unicellular exocrine glands. [NCERT Pg. 102]
4. _____ junctions help to stop substances from leaking across a tissue. [NCERT Pg. 102]
5. _____ junctions facilitate the cells to communicate with each other by connecting the cytoplasm of adjoining cells, for rapid transfer of ions, small molecules and sometimes big molecules. [NCERT Pg. 102]
6. Areolar tissue is present beneath the _____ and often serves as a support framework for epithelium [NCERT Pg. 103]
7. _____ cells secrete fibres and matrix. [NCERT Pg. 103]
8. _____ are phagocytic cells of connective tissue. [NCERT Pg. 103]
9. Cells of _____ tissue are specialized to store fats. This tissue is located mainly beneath the _____. [NCERT Pg. 103]
10. _____, _____ and _____ are various types of specialized connective tissues. [NCERT Pg. 104]
11. The intercellular material of _____ is solid, pliable and resists compression. [NCERT Pg. 104]

12. Ground substance of bones is rich in _____ and _____ fibres which give bone its strength. [NCERT Pg. 104]
13. Osteocytes are present in the fluid filled spaces called _____. [NCERT Pg. 104]
14. The bones interact with _____ muscles attached to them to bring about movements. [NCERT Pg. 104]
15. Blood is a _____ connective tissue. [NCERT Pg. 104]
16. Muscle fibres are composed of numerous fine fibrils, called _____. [NCERT Pg. 104]
17. _____ junctions at _____ allow the cells of cardiac muscles to contract as a unit. [NCERT Pg. 105]
18. _____ fuse the plasma membranes of cardiac muscle cells and make them stick together. [NCERT Pg. 105]
19. _____ make up more than one-half the volume of neural tissue in our body. [NCERT Pg.105]
20. Arrival of the disturbance at the neuron endings, triggers events that may cause _____ or _____ of adjacent neurons. [NCERT Pg.106]

❑ ❑ ❑

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Structural Organisation in Animals: Animal Morphology

2B Chapter

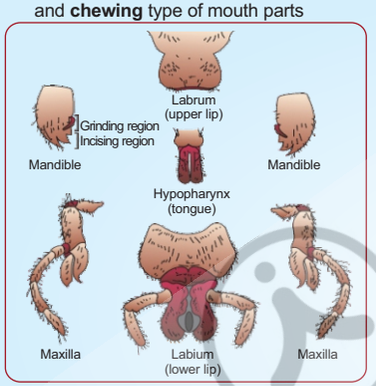
1 INTRODUCTION (Cockroach)

- **Classification**

Kingdom : Animalia **Phylum** : Arthropoda
Class : Insecta **Genus** : *Periplaneta*
Species : *americana*

- **Characteristics:**
  - **Size** : 34-53 mm long
  - **Colour** : Brown or black colour; Bright yellow, red and green coloured reported in tropical regions.
  - **Habitat** : Damp places throughout world
  - **Habit** : Nocturnal, Omnivorous
- **Economic importance** : Pests as they spoil food and contaminate with smelly excreta. Transmit several diseases by contaminating food material.

- Head bears appendages forming **Biting** and **chewing** type of mouth parts



2 MORPHOLOGY

- Body divisions → Head – 6 segments; Thorax – 3 segments; Abdomen – 10 segments
- **Wings extend** beyond the tip of **abdomen in males.**

- **Exoskeleton** : Hard, brown **chitinous** plates called **sclerites** → **Dorsal** plates – **Tergites**; **Ventral** plates – **Sternites**

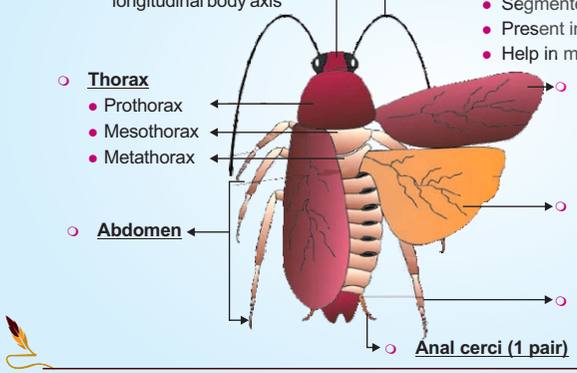
Plates connected by a thin, flexible articular/ **arthrodial membrane**.

Body Divisions:

- **Head**
  - Triangular, right angle to longitudinal body axis
- **Thorax**
  - Prothorax
  - Mesothorax
  - Metathorax
- **Abdomen**

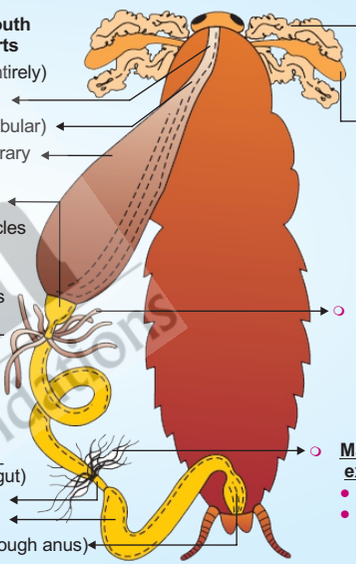
Appendages:

- **Filiform antennae**
  - Long, sensory thread like
  - Segmented arise from membranous socket
  - Present in front of eyes
  - Help in monitoring environment
- **Mesothoracic wings/ Forewings/ Tegmina (1 pair)**
  - Opaque, dark and leathery
  - Cover hindwings at rest
- **Metathoracic wings/ Hindwings (1 pair)**
  - Transparent and membranous
  - **Meant for flight**
- **Legs (3 pairs)**
  - 1 pair of walking legs on each thoracic segment
- **Anal cerci (1 pair)**



- Head connected to thorax by short extension of prothorax known as **neck**. It provide great mobility of head in all directions.

3 DIGESTIVE SYSTEM



Alimentary canal

Well developed with a mouth surrounded by mouth parts

- **Foregut** (Lined by cuticle entirely)
  - **Pharynx** (shorts tubular)
  - **Oesophagus** (Narrow tubular)
  - **Crop** (sac like for temporary **storage of food**)
  - **Gizzard/proventriculus**
  - Outer thick circular muscles and inner six chitinous teeth
  - Grinding of food particles
- **Mesenteron/ Midgut** (Between forgut and hindgut)
- **Hindgut** (Broader than midgut)
  - **Ileum**
  - **Colon**
  - **Rectum** (Opens out through anus)

Accessory glands

- **Salivary gland**
  - 1 pair
  - Present near crop
- Salivary reservoir
- **Hepatic/gastric caecae**
  - Ring of 6-8 blind tubules
  - At the junction of foregut and midgut
  - Secrete digestive juice
- **Malpighian tubules (part of excretory system)**
  - 100-150 in number
  - Yellow coloured, thin filamentous tubules at the junction of midgut and hindgut

4 BLOOD VASCULAR SYSTEM

- **Open type**

Heart

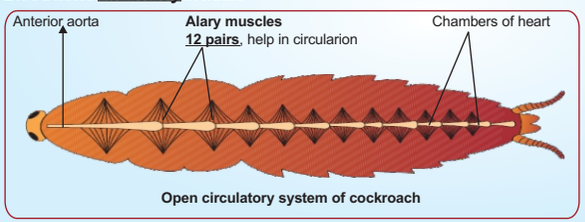
- Elongated muscular tube with **13 chambers**
- Lying along mid dorsal line of thorax and abdomen
- Funnel shaped chambers with **ostia** on either side
- Blood flows **anteriorly** in heart

Blood vessels

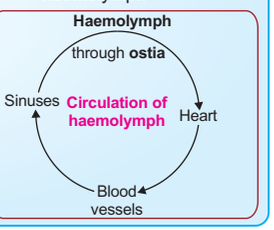
- Poorly developed
- Open into haemocoel

Haemolymph

- Composed of colourless plasma and **haemocytes**
- Visceral organs bathed in haemolymph



Open circulatory system of cockroach



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5 RESPIRATORY SYSTEM

- **Structures involved:** Network of trachea (thin, branching tubes) that open through **10 pairs of spiracles** present on **lateral side** of the body
- Opening of spiracles is guarded by **sphincters**
- **Site for exchange of gases:** Tracheoles by **diffusion**.

6 EXCRETORY SYSTEM

- **Structure involved:** Malpighian tubules, lined by **glandular** and **ciliated** cells.
- They absorb nitrogenous waste products and convert them into **uric acid** which is excreted out through hindgut.
- **Excretory product:** Uric acid **(Uricotelic)**
- **Other excretory structures:** Fat body, nephrocytes and uricose glands.

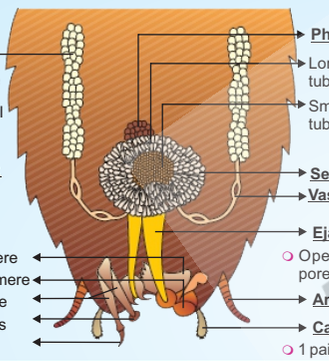
7 NERVOUS SYSTEM

Parameters	Head	Ventral part of body
Proportion of nervous system	Bit of nervous system	Most part of nervous system
Structure	Supra-oesophageal ganglion (brain) → Supply nerves to Antennae and compound eyes (Each compound eye consists of **2000** hexagonal **ommatidia**)	Paired longitudinal connectives with series of fused ganglia • **3 ganglia** in **thorax** and **6** ganglia in **abdomen**.

- **Sense organs:** Antennae, Labial palps, Eyes, Maxillary palps, Anal cerci
- Cockroach has **mosaic vision** with **more sensitivity and less resolution**
- If head of cockroach is cut off, it will still live for as long as one week

8 REPRODUCTIVE SYSTEM

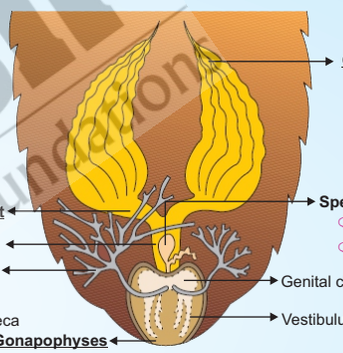
MALE REPRODUCTIVE SYSTEM



- **Testis**
  - 1 pair, lateral side
  - 4th-6th abdominal segments
- **Phallic gland**
  - Long tubules → **Mushroom gland**
    - 6th-7th abdominal segments
    - Accessory reproductive gland
  - Small tubules
- **Seminal vesicle**
- **Vas deferens**
- **Ejaculatory duct**
  - Opens through male genital pore which is ventral to anus
- **Anal cercus**
- **Caudal/anal style**
  - 1 pair, **only in males**
- **External genitalia/ gonapophysis:**
  - **Functions:**
    1. **Chitinous asymmetrical** structure
    2. Present around male gonopore
    3. Three phallomeres
  - **Components:**
    1. Right phallomere
    2. Ventral phallomere
    3. Left phallomere
    - Pseudopenis
    - Titillator

Male genital pouch is bounded dorsally by 9th and 10th terga and ventrally by 9th sternum.

FEMALE REPRODUCTIVE SYSTEM



- **Ovary**
  - 1 pair
  - 2nd-6th abdominal segments
  - 1 ovary contains 8 ovarioles
    - Each ovariole contains chain of developing ova
- **Spermatheca**
  - 1 pair
  - 6th abdominal segment
- **Oviduct**
- **Common oviduct/vagina**
- **Collaterial gland**
  - 1 pair
  - Secrete ootheca
- Genital chamber
- Vestibulum
- Genital pouch
- **Gonapophyses**

- Genital pouch is bounded by 7th sternum (boat shaped) along with 8th and 9th sterna
- Anterior part of genital pouch: female gonopore, spermathecal pores and collaterial glands

Path of sperms

- Testes → Vas deferens → Seminal vesicle → Ejaculatory duct → Male genital pore → Spermatheca of female during copulation

Path of ova

- Female genital pore ← Common oviduct/Vagina ← Oviduct ← Ovary (Ovarioles)

Sperms + Ova

- **Female genital pouch**
- Fertilisation
- Secretion of **collaterial glands** form ootheca
- On an average female produces **9-10 ootheca**, each containing **14 to 16 fertilised eggs**

- Female deposits ootheca in crack or crevice
- Nymph —**13 times moulting (Paurometabolous development)**→ Adult
- Next to last nymphal stage has **wing pads** but only adult cockroaches have wings.

Anal cerci	Anal style
Paired, long	Paired, short
Jointed	Unjointed
Filamentous	Thread like
♀ and ♂	♂

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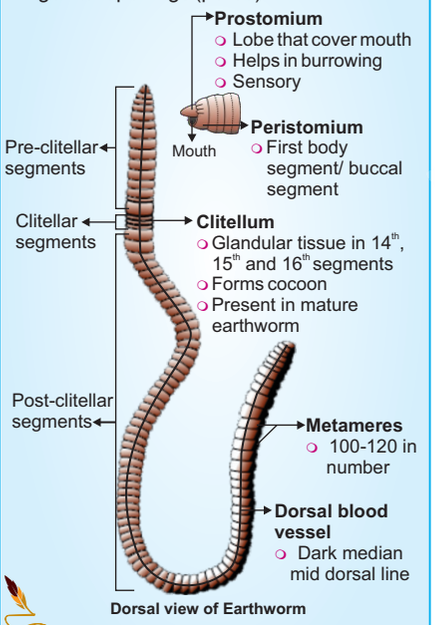
9 INTRODUCTION (EARTHWORM)

- **Phylum :** Annelida
- **Habitat:** Upper layer of the moist soil
- During day, live in burrows (made by boring and swallowing the soil
- Can be traced by faecal deposits known as **worm castings**
- *Pheretima* and *Lumbricus* are common Indian earthworms

10 MORPHOLOGY

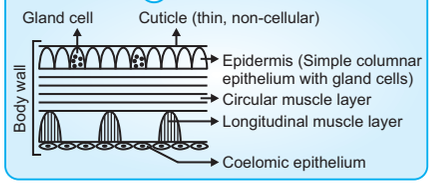
- Long cylindrical body
- 100-120 segments/metameres
- **Dorsal side:** Marked by mid dorsal line (Dorsal blood vessel)
- **Ventral side:** Marked by presence of genital openings (pores)



Dorsal view of Earthworm

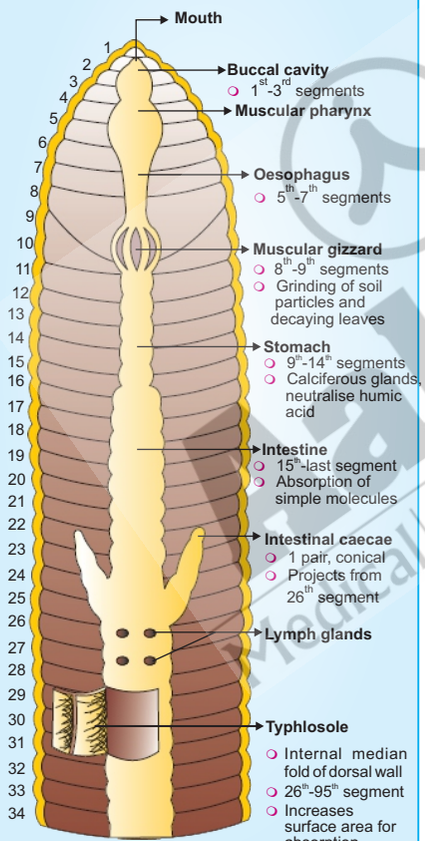
- **Setae:** S-shaped, ring of setae embedded in epidermal pits, present on each body segment except first, last and clitellum. Can extend or retract and helps in locomotion

11 ANATOMY



12 ALIMENTARY CANAL

- Straight tube between first and last segment
- Starts from mouth and opens to the exterior by rounded anus.



13 CIRCULATORY SYSTEM

- Closed type
- 4 pairs of tubular hearts, blood vessels and capillaries
  - **Lateral oesophageal hearts**
    2 pairs, 7th and 9th segments
  - **Lateral hearts**
    2 pairs, 12th and 13th segments
- **Dorsal blood vessel is largest blood vessel**
- **Anterior loops**-1 pair, 10th & 11th segments
- **Blood glands** 4th, 5th and 6th segments, they produce blood cells (phagocytic) and haemoglobin which is dissolved in blood plasma.

14 RESPIRATION

- Moist body surface (**cutaneous** respiration)

15 EXCRETORY ORGANS

- Nephridia (segmentally arranged coiled tubules)
  - 3 types (Similar in structure)

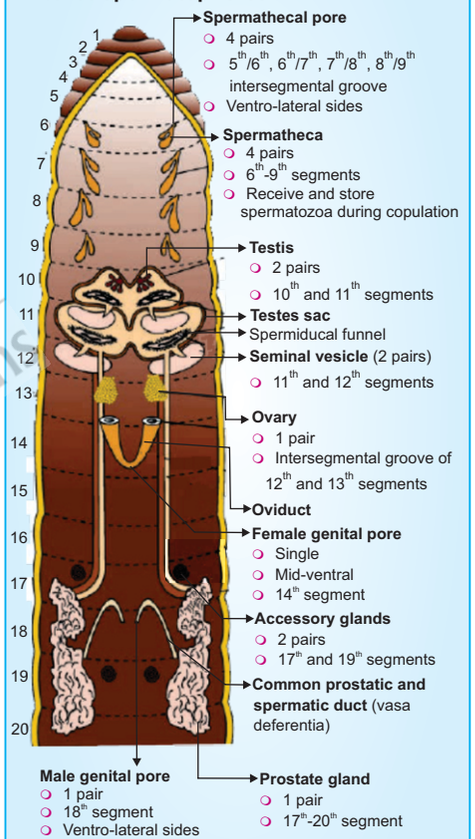
1. **Septal nephridia**
   - On both sides of intersegmental septa of 15th to last segment
   - Open into intestine
2. **Integumentary nephridia**
   - Attached to inner lining of body wall from 3rd to last segment
   - Open on the body surface through a pore
   - **Forest of integumentary nephridia** on clitellar segments
3. **Pharyngeal nephridia**
   - 3 paired tufts in 4th, 5th and 6th segments

16 NERVOUS SYSTEM

- Represented by ganglia arranged segment wise on the ventral paired nerve cord.
- The nerve cord in the anterior region (3rd and 4th segments) bifurcates, laterally encircling the pharynx and joins the cerebral ganglia dorsally to form a **nerve ring**.
- Receptor cells for light, touch and taste are present on anterior part. **Eyes absent.**

17 REPRODUCTIVE SYSTEM

- Hermaphrodite (bisexual)
- **Protandrous** condition, cross fertilisation
- Mutual exchange of sperms occur between two worms during mating
- Mate in **Juxtaposing opposite** gonadal openings exchanging packets of sperms called **spermatophores**



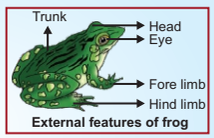
- **Fertilisation** and **development** occurs in **cocoons** produced by clitellum which are deposited in soil.
- After about **3 weeks** each cocoon produces **2-20 baby** worms with an **average of 4**
- Direct development (No **larval stage**)

18 INTRODUCTION (FROG/*Rana tigrina*)

- **Class:** Amphibia
- **Habitat:** Fresh water and land
- **Habit:** Poikilotherms, camouflage, undergo aestivation (summer sleep) and hibernation (winter sleep), never drink water but absorb through skin
- **Economic importance:**
  - Beneficial to mankind as they eat insects and protect the crops
  - Maintain ecological balance as they serve as link of food chain and food web in the ecosystem.
  - Muscular legs are used as food in some countries

19 MORPHOLOGY

- **Dorsal side:** Olive green with dark irregular spots.
- **Ventral side:** Pale yellow
- **Body division:** Head and Trunk,
  Neck and Tail absent
- **Limbs** helps in swimming, walking, leaping, burrowing



External features of frog

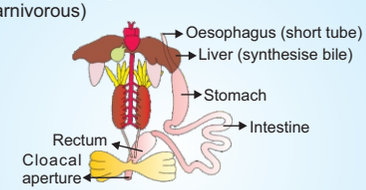
Parameter	Forelimbs	Hindlimbs
Digits	4	5
Size	Smaller	Larger and more muscular
Web	×	✓, for swimming

- Show sexual dimorphism

Parameter	Male	Female
Copulatory pad	First digit of forelimb	×
Vocal sac	Prominent	×

20 DIGESTIVE SYSTEM

Alimentary canal	Digestive glands
(Short because frogs are carnivorous)	Liver, pancreas



- Food is captured by the **bilobed tongue**
- Digestion of food by the action of HCl and gastric juices occur in stomach and is called **Chyme**
- Bile (emulsifies fat) and pancreatic juice through common bile duct digest carbohydrates and proteins in intestine
- **Digestion completes in small intestine**
- Digested food is absorbed by **villi and microvilli**
- Undigested waste moves into the rectum and passes out through cloaca

21 RESPIRATION

Location/during	Mode of respiration
Water, hibernation, aestivation	Cutaneous (highly vascularised
Land	Cutaneous, buccal cavity, pulmonary

- Lungs are a pair of elongated pink coloured sac-lik structures present in the thorax
- **Pulmonary respiration:** Air → Nostrils → buccal cavity → lungs

22 CIRCULATORY SYSTEM

- **Closed** type with single circulation
- Three chambered heart (two atria and one ventricle) covered by **pericardium**
- **Sinus venosus** (triangular) joins the right atrium
- Ventricles opens into a sac like **conus arteriosus** on the ventral side of the heart

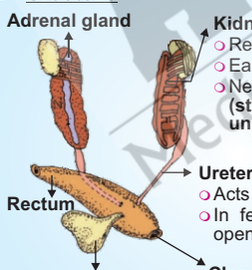
Liver ← Hepatic Portal system ← Intestine

Kidneys ← Renal Portal system ← Lower parts of the body

- **Blood:**
  Nucleated RBCs/erythorocytes contain haemoglobin, WBC's/leucocytes & platelets
- **Lymphatic system:** Lymph (lacks few proteins and RBCs), lymph channels, Lymph nodes

23 EXCRETORY SYSTEM

- **Ureotelic**



Kidney
- Red, bean like
- Each side of vertebral column
- Nephron/uriniferous tubule **(structural and functional unit)**

Ureter
- Acts as urinogenital duct in males
- In females, ureter and oviduct open separately in cloaca

Urinary bladder
- Red, bean like
- Ventral to rectum
- Opens in cloaca

Cloaca
- Small, median chamber
- Helps store & pass faecal matter, urine and sperms to the exterior via cloacal aperture

24 CONTROL AND COORDINATION

- Include neural system and endocrine glands

Neural systems

CNS
- Brain enclosed in cranium
- Spinal cord enclosed in vertebral column

PNS
- Cranial nerves **(10 pairs)**
- Spinal nerves
- ANS

Forebrain
- Olfactory lobes
- Cerebral hemispheres (Paired)
- Unpaired diencephalon

Midbrain
- Optic lobes (Paired)

Hindbrain
- Cerebellum
- Medulla oblongata (Passes through foramen magnum and continues into spinal cord)

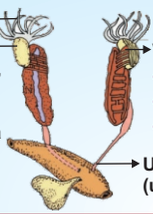
- **Sense organs**
  - Sensory papillae – Touch
  - Taste buds – Taste
  - Nasal epithelium – Smell
  - Simple eyes – Vision
  - Ear – Hearing and equilibrium

  Cellular aggregations around nerve endings

  Well organised structures
  - External ear is absent in frogs.
- **Endocrine glands**
  - Pituitary, thyroid, parathyroid, thymus, pineal body, pancreatic islets, adrenals and gonads

25 REPRODUCTIVE SYSTEM

Male



Testis
- 1 pair, yellowish, ovoid
- Attached to upper part of kidneys by a double fold of peritoneum called **mesorchium**

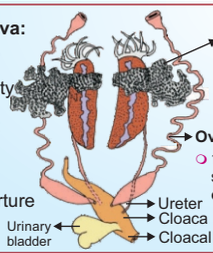
Vasa efferentia
- 10-12 in number
- Open into **Bidder's canal**
- Finally communicates with urinogenital duct

Urinogenital duct (ureter)

Route of sperm:
Testis → Vasa efferentia → Bidder's canal → Urinogenital duct → Cloaca → Cloacal aperture

Female

Route of ova:
Ovaries → Body cavity → Oviduct → Cloaca → Cloacal aperture



Ovary
- 1 pair, near kidneys
- **No functional connection with kidneys**

Oviduct
- 1 pair, opens separately into **cloaca**

- A mature female can lay 2500 to 3000 ova at a time.
- Fertilisation is external and takes places in water.
- Development involves a larval stage called **tadpole**. Tadpole undergoes metamorphosis to form the adult.

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Sharpen Your Understanding

1. All of the following characteristics describe sexual dimorphism in *Periplaneta americana*, **except** [NCERT Pg. 111]
   (1) Wings extend beyond the tip of abdomen in males
   (2) 7^{th} sternum is boat shaped in females
   (3) Anal styles are present in males and absent in females
   (4) Anal cerci are present in females and absent in males
2. The first pair of wings in cockroach arises from [NCERT Pg. 112]
   (1) Prothorax (2) Pronotum
   (3) Mesothorax (4) Metathorax
3. Transparent, membranous wings which are used in flight in cockroach are [NCERT Pg. 112]
   (1) Mesothoracic wings
   (2) Metathoracic wings
   (3) Tegmina
   (4) Forewings
4. Hepatic caecae are present at the junction of [NCERT Pg. 113]
   (1) Proventriculus and foregut
   (2) Gizzard and midgut
   (3) Midgut and hindgut
   (4) Crop and gizzard
5. Choose the **mismatch** w.r.t. cockroach [NCERT Pg. 113]
   (1) Abdomen – 10 segments
   (2) Anal cerci – 10^{th} segment
   (3) Malpighian tubules – 100-150
   (4) Tracheal system – 10 spiracles
6. Grinding of food first occurs by which structure in cockroach? [NCERT Pg. 112 & 113]
   (1) Six chitinous teeth in gizzard
   (2) Crop
   (3) Mandible
   (4) Maxillae
7. Which of the following is **incorrect** w.r.t. circulatory system of cockroach? [NCERT Pg. 113]
   (1) Open circulatory system
   (2) Blood vessels are absent
   (3) Haemocytes are present in haemolymph
   (4) Haemolymph flows in heart anteriorly
8. Exchange of gases in cockroach take place at the [NCERT Pg 114]
   (1) Trachea (2) Tracheoles
   (3) Spiracles (4) Ostia
9. Read the following statements and choose the **correct** option.
   Statement-A : Nervous system of cockroach consists of a series of fused, segmentally arranged ganglia joined by paired longitudinal connectives.
   Statement-B : In cockroach, head holds a bit of a nervous system while the rest is situated along the dorsal part of the body. [NCERT Pg.114]
   (1) Statement A is incorrect
   (2) Statement B is correct
   (3) Both A and B statements are incorrect
   (4) Only statement B is incorrect
10. Nerves from supra-oesophageal ganglion in cockroach innervates A and B. Choose the option which **correctly** fill the blanks A and B. [NCERT Pg. 114]

	A	B
(1)	Antennae	Compound eyes
(2)	Labrum	Labium
(3)	Antennae	Labium
(4)	Compound eyes	Mandibles

11. Match the following columns w.r.t. cockroach and choose the **correct** option [NCERT Pg. 114]

	Column-I		Column-II
a.	Testes	(i)	6^{th} abdominal segment
b.	Ovary	(ii)	4^{th}-6^{th} abdominal segments
c.	Mushroom gland	(iii)	2^{nd}-6^{th} abdominal segments
d.	Spermatheca	(iv)	6^{th}-7^{th} abdominal segments

(1) a(ii), b(iii), c(iv), d(i)
(2) a(iii), b(ii), c(i), d(iv)
(3) a(iv), b(iii), c(i), d(ii)
(4) a(i), b(ii), c(iv), d(iii)

12. In female cockroach, sperms are stored in [NCERT Pg. 114]
(1) Seminal vesicles
(2) Spermatheca
(3) Ejaculatory duct
(4) Vagina

13. Ootheca, which is dark reddish to blackish brown capsule, about 3/8" (8 mm) long is formed by the secretions of [NCERT Pg. 114]
(1) Mushroom gland
(2) Phallic gland
(3) Collaterial glands
(4) Long tubules of male accessory gland

14. Choose the **odd** one w.r.t. external genitalia in male cockroach [NCERT Pg. 112, 114, 115]
(1) 3 pairs of gonapophyses
(2) Chitinous asymmetrical structures
(3) Pseudopenis and titillator are part of left phallomere
(4) Present in male genital pouch, ventral to anus

15. Posterior part of female genital pouch is called [NCERT Pg. 115]
(1) Vestibulum
(2) Vagina
(3) Genital chamber
(4) Gonapophyses

16. Select the **incorrect** statement w.r.t. sensory system in earthworm. [NCERT Pg. 110]
(1) Eyes are absent but receptor cells are present to distinguish light intensities
(2) Receptor cells for touch are present to feel vibrations in the ground
(3) Sense organs are located on the anterior part of earthworm
(4) Taste receptors (chemoreceptors) are absent in earthworm

17. Earthworms are known as "Friends of Farmers" because [NCERT Pg. 108, 111]
a. They make the soil porous
b. Increases soil fertility
c. Larger soil particles are grind up into finer ones
d. They neutralises humic acid present in the soil.
How many of the above statements are **correct**?
(1) Four
(2) Three
(3) Two
(4) One

18. Which of the following structure acts as urino genital duct in male frogs? [NCERT Pg.118]
(1) Urethra
(2) Ureters
(3) Urinary bladder
(4) Vasa efferentia

19. Male frog can be distinguished externally from female frog by all of the following features **except** [NCERT Pg. 116]
a. Presence of sound producing vocal sacs
b. Presence of copulatory pad on the first digit of the forelimbs
c. Ureters carry both sperms and urine in male frog
d. Testes are adhered to the upper part of kidneys by a double fold of peritoneum called mesorchium
(1) a, b, c and d
(2) a and b only
(3) a, b and c only
(4) c and d only

20. On land, frog respires by [NCERT Pg. 118]
(1) Skin only
(2) Skin and buccal cavity only
(3) Skin, lungs and buccal cavity
(4) Lungs only

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Thinking in Context

1. Size of cockroaches ranges from _____ inches to _____ inches (____to ____ cm). [NCERT Pg. 111]
2. Head of cockroach is formed by fusion of _____ segments and lies anteriorly at _____ angle to the longitudinal body axis, head shows greater mobility in all directions due to flexible _____. [NCERT Pg. 112]
3. In female cockroach, _____ is boat shaped and together with _____ and _____ forms a blood or genital pouch. [NCERT Pg. 112]
4. Anterior part of genital pouch in female cockroach contains _____, _____ and _____. [NCERT Pg. 112]
5. In male cockroach, genital pouch or chamber is bounded dorsally by _____ and _____ and ventrally by the _____. [NCERT Pg. 112]
6. Male genital pouch in cockroach contains dorsal _____, ventral _____ and _____. [NCERT Pg. 112]
7. In cockroach excretion is performed by _____. In addition, the _____, _____ and _____ also help in excretion. [NCERT Pg. 114]
8. Malpighian tubules are lined by _____ and _____ cells. They absorb _____ waste products and convert them into _____ which is excreted out through the _____. [NCERT Pg. 114]
9. In cockroach, brain is represented by _____ [NCERT Pg. 114]
10. Each compound eye consists of _____ hexagonal ommatidia. _____ vision is present in cockroach with more _____ and less _____. [NCERT Pg. 114]
11. On an average, a female cockroach produces _____ ootheca, each containing _____ eggs. [NCERT Pg. 115]
12. The development of *Periplaneta americana* is _____. The nymph grows by moulting about _____ to reach the adult form. [NCERT Pg. 115]
13. The _____ nymphal stage has _____ but only _____ cockroaches have wings. [NCERT Pg. 115]
14. In cockroach, the ejaculatory duct opens into _____ situated _____ to anus. [NCERT Pg. 114]
15. In cockroach, each ovary is formed of a group of _____ ovarioles. Oviducts of each ovary unite into a single median _____. [NCERT Pg. 114]
16. The process of increasing fertility of soil by the earthworms is called _____. [NCERT Pg. 111]
17. The characteristic feature of the intestine of earthworm is the presence of internal median fold of dorsal wall called _____. This increases area of _____. [NCERT Pg. 108]
18. Summer sleep is called _____ and winter sleep is called _____. [NCERT Pg. 116]
19. Vasa efferentia in frog are _____ in number that arise from _____. They enter the kidneys on their side and open into _____. [NCERT Pg. 119]
20. _____ of cranial nerves are present in frog. [NCERT Pg. 119]

❑ ❑ ❑

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Biomolecules

3 Chapter

1 BIOMOLECULE

- All the carbon compounds that we get from living tissues can be called '**biomolecules**'. However, living organisms have also got **inorganic elements** and **compounds** in them.

Chemical Analysis

Living tissue (Plant tissue/animal tissue/microbial paste) + **Trichloroacetic acid (Cl_3CCOOH)**

↓

Thick slurry

↓

→ Cheese cloth

Filtrate (Acid soluble)
Roughly **cytoplasmic components**

Retentate (Acid insoluble)

↓

Organic Biomacromolecules
- M.wt - > 10,000 Da
- Polymeric form

Polysaccharides
Nucleic acids
Proteins

Lipids (Not a polymer)

↓

- Not strictly biomacromolecule
- M.wt < 800 Da
- Cell membrane fragments form vesicles which are not water soluble

Inorganic
- Water
- Ions (e.g. Na^+, K^+, Ca^{+2}, Mg^{+2}, PO_4^{-3}, SO_4^{-2}, etc.)
- Gases

Organic Biomicromolecules
- M.wt - 18-800 Da
- Monomeric form

E.g., Simple sugars → Polysaccharides
Nucleotides → Nucleic acids
Amino acids → Proteins

2 ELEMENTAL ANALYSIS

- Elemental analysis gives elemental composition of living tissues in the form of hydrogen, oxygen, chlorine, carbon etc.
- Living tissue — Weigh → **Wet weight**; Dry (All water evoporates) → **Dry weight**
- Dried living tissue — Burn (All carbon compounds oxidise to CO_2 and H_2O) → **'Ash' (contains only inorganic elements)**
- Carbon and hydrogen with respect to other elements are more in any living organisms than in earth's crust
- **Oxygen is the most abundant element in living organism**
- Analytical technique gives an idea about the molecular formula and the probable structure of the compound.

Comparison of Elements Present in Non-living and Living Matter

Element	% Weight of Earth's crust	Human body
Hydrogen (H)	0.14	0.5
Carbon (C)	0.03	18.5
Oxygen (O)	46.6	65.0
Nitrogen (N)	very little	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	negligible

Average Composition of Cells

Component	% of the total cellular mass
Water	70-90
Proteins	10-15
Nucleic acids	5-7
Carbohydrates	3
Lipids	2
Ions	1

Water **is the most abundant chemical** in living organisms

3 METABOLITES (BIOMOLECULES)

Primary metabolite
- Identifiable functions
- Play known **roles in physiological** processes e.g. sugars, amino acids lipids, nitrogen bases, etc.

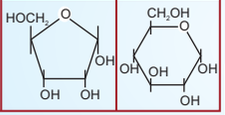
Secondary metabolite
- Not involved in primary metabolism
- Seems to have **no direct function** in growth and development of organisms
- Many of them are useful to **human welfare** e.g., rubber, drugs, spices and pigments. Some have **ecological importance**
- E.g., Flavonoids, antibiotics etc.

Some Secondary Metabolites

Pigments	Carotenoids, Anthocyanins
Alkaloids	Morphine, Codeine
Terpenoides	Monoterpenes, Diterpenes
Essential oils	Lemon grass oil
Toxins	Abrin, Ricin
Lectins	Concanavalin A
Drugs	Vinblastin, curcumin
Polymeric substances	Rubber, gums, cellulose

4 CARBOHYDRATES

Monosaccharides/sugar
- Single unit

No. of Carbon	5C	6C
Formula	$C_5H_{10}O_5$	$C_6H_{12}O_6$
Example	Ribose	Glucose
Structure		

- Glycogen → **Right end** is **reducing** while **left end** is **non-reducing**
- Starch hold I_2 in helical portion
- Cellulose can not hold I_2 as no helical portion
- Cotton fibre → Cellulose
- Paper is made from plant pulp

Polysaccharides
- Many units/long chains of sugars
- Units linked together by **glycosidic bond** formed by **dehydration**.

Homopolysaccharides
- Same monomer units

Heteropolysaccharides
- Different monomer units

Features	Glycogen	Starch	Inulin	Cellulose	Chitin
Found in	Animals	Plants	Plants	Plants	Animals
Function	Storage	Storage		Cell wall (Structural)	**Exoskeleton of arthropods**
Monomer	Glucose		Fructose	Glucose	**N-acetyl glucosamine**
Branching	✓				
Colour with I_2	Red	Blue		X	

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5 NUCLEIC ACIDS

- **Polymer of nucleotides**
- Each nucleotide comprises
  - Sugar/monosaccharide
  - Heterocyclic nitrogenous base
  - Phosphate

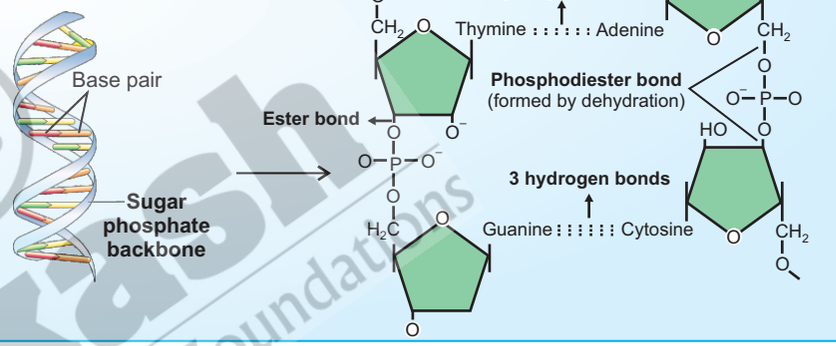
→ **Nucleoside** → **Nucleotide**

Nitrogenous base	Nucleoside	Nucleotide
Substituted **Purines**: Adenine; Guanine	Adenosine; Guanosine	Adenylic acid; Guanylic acid
Substituted **Pyrimidine**: Thymine; Cytosine; Uracil	Thymidine; Cytidine; Uridine	Thymidylic acid; Cytidylic acid; Uridylic acid

- **Ribose sugar** and **uracil** exist in **RNA** (Ribonucleic acid)
- 2′-deoxyribose sugar and thymine exist in DNA (Deoxyribonucleic acid)
- DNA and RNA function as genetic material

Wastson-Crick model of B-DNA

- DNA exists as double helix **(secondary structure)**
- Two polynucleotide strands are **helically coiled around a common axis**
- The two polynucleotide strands are **antiparallel** *i.e.*, run in opposite direction and **complementary** to each other
- A and G of one stand compulsorily base pairs with T and C respectively, on the other strand
- Always two hydrogen bonds exist between A and T and three hydrogen bonds between C and G
- **Phosphate moiety links 3′-carbon of one sugar of one nucleotide to 5′ carbon of sugar of succeeding nucleotide**
- Nitrogen bases are perpendicular to backbone and **faces inside**.
- At each step of ascent, strand turns **36°**
- **1 turn = 10 base pairs**
- **1 complete turn = 34Å**
- **Rise per base pair = 3.4Å**



6 LIPIDS

- Generally **water insoluble**
- Could be simple fatty acids (R – COOH) where R group could be
  - Methyl ($-CH_3$), ethyl ($-C_2H_5$), higher no. of $-CH_2$ (C–1 to 19)
- Types of fatty acids

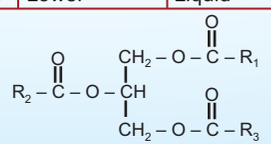
Parameter	Saturated	Unsaturated
No. of C = C double bonds	X	One or more
Example	**Palmitic acid** (**16** carbon including carboxyl carbon) $CH_3 - (CH_2)_{14} - COOH$	**Arachidonic acid** (**20** carbon including carboxyl carbon)

I. Many lipids are **esters of fatty acids and glycerol**

Type	No. of fatty acids	Glycerol (trihydroxy propane)
Monoglyceride	1	1
Diglyceride	2	1
Triglyceride	3	1

$CH_2(OH) - CH(OH) - CH_2(OH)$

	Melting point	State in winters	Examples
Fats	Higher	Solid	Ghee, Butter
Oils	Lower	Liquid	Gingelly oil

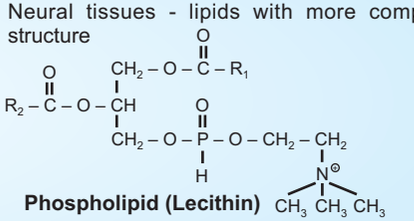


Triglyceride (R_1 R_2 and R_3 are fatty acids)

II. Some lipids have phosphorous and phosphorylated organic compound called **phospholipids**

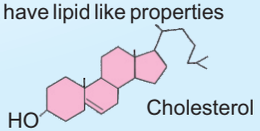
e.g., Lecithin - **found in cell membrane**

Neural tissues - lipids with more complex structure



Phospholipid (Lecithin)

III. Cholesterol, have lipid like properties



7 AMINO ACIDS

- Organic compounds containing an amino group and an acidic group as substituents on same carbon i.e., α-**carbon**, hence called α-amino acids.
- **Substituted methane**, four substituent groups occupying four valency positions.
- Chemical and physical properties of amino acids are essentially of amino, carboxyl and R-functional groups

Types of amino acids

I. On the basis of **R-group**

R-group	Amino acids
–H	Glycine
$-CH_3$ (methyl)	Alanine
$-CH_2-OH$ (hydroxy methyl)	Serine

II. On the basis of **Nature** of amino acids

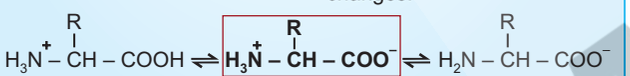
Nature	Amino acids
Acidic	Glutamic acid
Basic	Lysine
Neutral	Valine
Aromatic	Tyrosine, tryptophan, phenylalanine

III. On the basis of **Body's requirement**

Non-essential	Essential
Synthesised by body	Not synthesised by body
Not required in diet	Required in diet

Zwitterionic Form

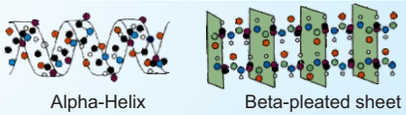
- A particular property of amino acids is the ionisable nature of $-NH_2$ and –COOH group.
- In solutions of different pH the structure of amino acids changes.



Zwitterionic form
(Both positive and negative charge)

8 STRUCTURE OF PROTEINS

- Each protein is a **heteropolymer** of amino acids linked by **peptide bonds** (formed by **dehydration**) and only **20 types** of amino acids participate in their formation.
- Biologists describe structure of proteins at four levels :

Level	Typical	Structure
Primary	❍ **Positional information** of sequence of amino acids ❍ Protein thread as extended rigid rod	NH_2 COOH **Left end** ❍ N-terminal ❍ First amino acid **Right end** ❍ C-terminal ❍ Last amino acid
Secondary	❍ Thread folded in the form of a helix *i.e.*, similar to revolving stair case ❍ **Only right handed** helices observed in proteins	 Alpha-Helix Beta-pleated sheet
Tertiary	❍ 3-dimensional view, like hollow woolen ball ❍ This structure is **absolutely necessary for many biological activities of proteins**	 Hydrogen bond Disulphide bond
Quaternary	❍ More than one polypeptide chains are involved eg. **Haemoglobin** consists of **4 subunits: 2α and 2β** ❍ It is based on how individual polypeptide are arranged with respect to each other	

9 SOME PROTEINS AND THEIR FUNCTIONS

Protein	Functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Insulin	Hormone
Antibody	Fights infectious agents
Receptor	Sensory reception (smell, taste, hormone)
GLUT-4	Enables glucose transport into cells

- **Collagen** is the most abduant protein in **animal** world
- **RuBisCO** is the most abduant protein in the whole of the **biosphere**

10 DYNAMIC STATE OF BODY CONSTITUENTS

- Living state is a **non-equilibrium steady** state to be able to perform work
- Living process is constant effort to prevent falling into equilibrium
- Living state and metabolism are synonymous.
- Without metabolism there can not be a living state
- **Metabolism** is sum total of **all the reactions** in the body
- There is **no uncatalysed metabolic conversion** in living system

Metabolic pathways (Series of linked reactions)

Catabolic pathways
- **Degradation** pathways
- Complex structure converts into simpler structure
- Energy released (stored in ATP)
- Examples
  - Glucose $\xrightarrow{\text{anaerobic}}$ Lactic acid (skeletal muscle)
  - Glucose $\xrightarrow{\text{anaerobic}}$ Ethanol (In yeast)
  - Glucose $\xrightarrow[\text{10 steps}]{\text{Glycolysis}}$ Pyruvic acid

Anabolic pathways
- **Biosynthetic** pathways
- Formation of complex structure from simple structures
- Energy is used
- Examples
  - Acetic acid → Cholesterol
  - Amino acids → Proteins

$$CO_2 + H_2O \underset{}{\overset{\text{Carbonic anhydrase}}{\rightleftharpoons}} H_2CO_3$$

- Carbonic anhydrase is present in cytoplasm
- With enzyme - 6,00,000 molecules of H_2CO_3 formed in 1 sec, Rate increases 10 million times
- Without enzyme - 200 molecules/hr

- Rate refers to the amount of product formed per unit time, expressed as $\text{rate} = \delta P/\delta t$
- Rate double or decreases by half for every 10°C change in either direction.
- Flow of metabolites through metabolic pathways has a definite direction, this is called dynamic state of body constituents
- Biomolecules are constantly being changed into some other biomolecules and also made from some other biomolecules called **turnover**
- Glucose concentration in blood : **4.2 - 6.1 m mol/L**

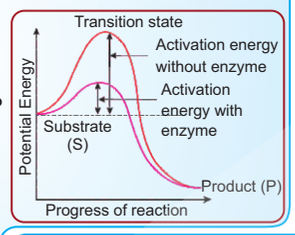
11 ENZYMES (BIOCATALYST)

Properties:

- **Tertiary** structure
- **Highly specific**
- Proteinaceous in nature except **ribozymes** (**nucleic acids**)
- Increases rate of reaction by **lowering activation energy**
- Have **active site**/pockets where **substrate** binds
- **Unchanged** at the end of reaction
- **Not used up** in the reaction
- Inorganic catalysts work efficiently at high temperatures and high pressures while enzymes get **denatured** at high temperature **(> 40°C)** except enzymes of **thermophilic** organisms (can **tolerate 80°-90°C**).
- For metabolic conversion, substrate **'S'** has to bind the enzyme at its active site and results in **obligatory** formation of **'ES' complex** (**Transient phenomenon**), essential for catalysis.
- Structure of substrate gets transformed into structure of product(s)

$$E + S \rightleftharpoons ES \longrightarrow EP \longrightarrow E + P$$

'Altered structural states' (unstable)



- Difference in average energy content of 'S' from that of transition state is called '**Activation energy**'
- **Transition state – High energy unstable state**
- 'P' is at lower level than 'S' – Reaction is **exothermic**
- 'S' is at lower level than 'P' – Reaction is **endothermic**

13 CLASSIFICATION AND NOMENCLATURE OF ENZYMES

- Thousands of enzymes have been discovered, isolated and studied. Most of these enzymes have been classified into different groups based on the type of reactions they catalyse. Enzymes are divided into **6 classes** each with **4-13 subclasses** and named accordingly by a four-digit number.

Class	Name	Function
I	**Oxidoreductases/ dehydrogenases:**	Enzymes which catalyse oxidoreduction between two substrates S and S' S reduced + S' oxidised → S oxidised + S' reduced.
II	**Transferases:**	Enzymes catalysing a transfer of a group, G (other than hydrogen) between a pair of substrate S and S'. $S-G+S' \longrightarrow S+S'-G$
III	**Hydrolases:**	Enzymes catalysing hydrolysis of ester, ether, peptide, glycosidic, C – C, C – halide or P-N bonds.
IV	**Lyases:**	Enzymes that catalyse removal of groups from substrates by mechanisms other than hydrolysis **leaving double bonds**. $\begin{matrix} X & Y \\ \vert & \vert \\ C- & C \end{matrix} \longrightarrow X-Y+C=C$
V	**Isomerases:**	Includes all enzymes catalysing inter-conversion of optical, geometric or positional isomers.
VI	**Ligases:**	Enzymes catalysing the linking together of 2 compounds, e.g., enzymes which catalyse joining of C-O, C-S, C-N, P-O etc. bonds.

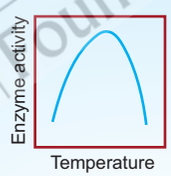
12 FACTORS AFFECTING ENZYME ACTIVITY

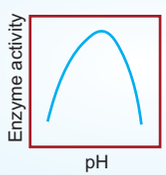
(1) Temperature

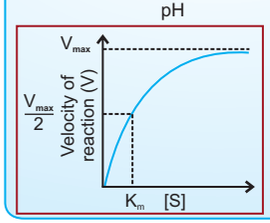
- Enzyme shows **highest activity at optimum** temperature
- Enzyme activity declines both below and above optimum value
- Low temperature preserves enzymes in temporarily **inactive** state
- High temperature destroys enzymatic activity by **denaturing** their structure

(2) pH

- Enzyme shows highest activity at optimum pH
- Rate of reaction declines both below and above optimum pH







(3) Substrate concentration

Initially rate of reaction increases with increase in substrate concentration but becomes constant when all enzymes get saturated with substrate

(4) Binding of specific chemicals

When binding of chemicals shuts off enzyme activity, the process is called **inhibition** and chemical is called **inhibitor**

Competitive inhibitor:

- Inhibitor compete with substrate for active site
- Closely **resembles substrate** in molecular structure and inhibits enzyme activity
- Consequently, substrate can not bind and as a result enzyme action declines.
- e.g., (1) Inhibition of succinic dehydrogenase by malonate
  (2) Control of bacterial pathogens by competitive inhibitor

14 CO-FACTORS

Enzymes

- Simple enzymes
  - Only protein
- Conjugated enzymes
  - **Apo-enzyme** (inactive)
    - Protein part
  - **Co-factor**
    - Non-protein part

Catalytically active enzyme

Catalytic activity is lost if co-factor is removed

Prosthetic group
- Organic, **tightly bound** to apoenzyme
- **Haem is prosthetic group** for **catalase** and **peroxidase**

Co-enzyme
- Organic, **loosely bound** to apo-enzyme for transient period (just during catalysis)
- e.g., **NAD, NADP** (Contain **niacin vitamin**)

Metal ions
- Form **coordination bond** with active site and one or more coordination bond with substrate
- Zn^{+2} for carboxypeptidase

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Sharpen Your Understanding

1. Select the **incorrect** statement w.r.t. elemental analysis of living and non-living matter [NCERT Pg. 143]
   (1) Oxygen is the most abundant element in the human body
   (2) All the elements present in earth's crust are also present in living organisms
   (3) 'Ash' analysis gives an idea about organic constituents of living tissue
   (4) Analytical techniques gives an idea about molecular formula and probable structure of the compound

2. For chemical analysis of living tissue, it is grind with [NCERT Pg.142]
   (1) $Cl_2CHCOOH$ (2) Cl_3CCOOH
   (3) $ClCH_2COOH$ (4) CH_3COOH

3. All the given molecules are present in retentate **except** [NCERT Pg. 142,146]
   (1) Lipids
   (2) Amino acids
   (3) Polysaccharide
   (4) Nucleic acids

4. Molecular weight of lipids is [NCERT Pg. 146]
   (1) Less than 800 Da
   (2) 10,000 Da
   (3) > 10,000 Da
   (4) < 18 Da

NCERT Based MCQs

5. Choose the **mismatch** w.r.t. average composition of cells [NCERT Pg. 147]
   (1) Protein – 10-15%
   (2) Lipids – 3%
   (3) Nucleic acids – 5-7%
   (4) Water – 70-90%

6. Select a secondary metabolite which is alkaloid also [NCERT Pg. 146]
   (1) Carotenoids (2) Morphine
   (3) Vinblastin (4) Ricin

7. Choose the **odd** one w.r.t. aromatic amino acids [NCERT Pg. 144]
   (1) Glycine
   (2) Tyrosine
   (3) Tryptophan
   (4) Phenylalanine

8. The chemical and physical properties of amino acids are essentially of the X, Y and the Z groups. Choose the option which is **correct** for X, Y and Z [NCERT Pg. 144]
   (1) X-amino, Z-Hydroxyl
   (2) Y-Hydroxyl, Z-R-group
   (3) Y-Carboxyl, Z-R-group
   (4) X-Carbonyl, Z-Hydroxyl

9. Select the statement which holds **true** for lipids [NCERT Pg. 144]
   (1) Arachidonic acid has 20C excluding carboxyl carbon
   (2) Palmitic acid has 18C carbon excluding carboxyl carbon
   (3) Glycerol is trihydroxy propane
   (4) Neural tissues have lipids with more simple structures

10. Select the amino acid which has extra amino group [NCERT Pg. 144]
    (1) Valine
    (2) Glutamic acid
    (3) Lysine
    (4) Tyrosine

11. Which of the following is zwitterionic form of amino acid? [NCERT Pg. 144]
    (1) $H_2N-\underset{\displaystyle R}{\underset{|}{C}}H-COOH$
    (2) $H_3N^+-\underset{\displaystyle R}{\underset{|}{C}}H-COO^-$
    (3) $H_3N^+-\underset{\displaystyle R}{\underset{|}{C}}H-COOH$
    (4) $H_2N-\underset{\displaystyle R}{\underset{|}{C}}H-COO^-$

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12. In a nucleotide, phosphate group is linked to A by B bond. Choose the option which **correctly** fill the blanks [NCERT Pg. 144]

	A	B
(1)	Adenine	Ester
(2)	Sugar	Ether
(3)	Nitrogen base	Glycosidic
(4)	Sugar	Ester

13. Select the neutral amino acid [NCERT Pg. 144]

(1) Tyrosine
(2) Phenylalanine
(3) Tryptophan
(4) Valine

14. Choose the **mismatch** w.r.t. components and the bond linking them [NCERT Pg. 144,151]

(1)	Monosaccharides	–	Glycosidic bond
(2)	Nucleotides	–	Phosphodiester bond
(3)	Glycerol and fatty acids	–	Ether bond
(4)	Amino acids	–	Peptide bond

15. Which of the following characteristics hold **true** for glycogen? [NCERT Pg. 148]

(1) Unbranched
(2) Structural polysaccharide of plants
(3) Right end is reducing
(4) Give blue colour with I_2

16. Sugar present in DNA is [NCERT Pg. 149]

(1) Glucose
(2) Ribose
(3) 2′deoxyribose
(4) 2-deoxyglucose

17. Which structure is absolutely necessary for the many biological activities of proteins? [NCERT Pg. 150]

(1) Primary (2) Secondary
(3) Tertiary (4) Quaternary

18. Pitch of B-DNA is [NCERT Pg. 152]

(1) 34Å (2) 0.34 nm
(3) 3.4 Å (4) 36Å

19. Which of the following is an example of biosynthetic pathway? [NCERT Pg. 153]

(1) Formation of cholesterol from acetic acid
(2) Formation of pyruvic acid from glucose
(3) Formation of amino acids from proteins
(4) Formation of ethanol from pyruvic acid

20. Enzyme which catalyses hydrolysis of peptide bond belongs to which class? [NCERT Pg. 158]

(1) Oxidoreductases (2) Hydrolases
(3) Lyases (4) Ligases

Thinking in Context

1. _____ and _____ with respect to other elements are abundant in any living organism than in earth's crust. [NCERT Pg. 142]

2. _____ are not strict biomacromolecules. [NCERT Pg. 147]

3. _____ is the most abundant chemical in living organisms. [NCERT Pg. 147]

4. Some secondary metabolites have _____ importance. [NCERT Pg. 146]

5. _____ metabolites have identifiable functions and play known roles in normal physiological processes. [NCERT Pg. 146]

6. Oils have _____ melting point and hence remain as oil in winters. [NCERT Pg. 144]

7. _____ amino acids are those which our body can make. [NCERT Pg. 147]

8. Chitin is a polymer of _____ which is present in _____ of arthropods. [NCERT Pg. 149]

9. Only _____ handed helices are observed in proteins. [NCERT Pg. 150]

10. Backbone of deoxyribose nucleic acid is formed by _____. [NCERT Pg. 151]

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11. In B-DNA, the change in angle per base pair rise is _____. [NCERT Pg. 152]

12. Living state is a _____ steady state to be able to perform work. [NCERT Pg. 153]

13. There is no _____ metabolic conversion in living system. [NCERT Pg. 152]

14. Almost all enzymes are _____. There are some _____ that behave like enzymes. These are called _____. [NCERT Pg. 154]

15. In presence of carbonic anhydrase, _____ molecules of H_2CO_3 are formed _____ second. [NCERT Pg. 155]

16. The difference in average energy content of substrate from that of transition state is called _____. [NCERT Pg. 156]

17. At low temperature, enzymes become _____, whereas at high temperature, they get _____. [NCERT Pg. 157]

18. When the inhibitor closely resembles the substrate in its molecular structure and inhibits the activity of the enzyme, it is known as _____ inhibitor. [NCERT Pg. 158]

19. _____ is the protein part of the enzyme. [NCERT Pg. 159]

20. _____ groups are organic co-factors and are tightly bound to the apo-enzyme. _____ is the prosthetic group for peroxidase and catalase. [NCERT Pg. 159]

❑ ❑ ❑

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Digestion and Absorption

4 Chapter

1 BASIC REQUIREMENTS OF LIVING ORGANISMS

Digestion: The process of conversion of complex food substances to simple absorbable forms by mechanical and biochemical methods.

1. Food: ❍ Provide **energy** and organic material for **growth** and **repair of tissues**.

- **Major components**: • Carbohydrates, Proteins, Fats
- **Minor components**: • Vitamins, Minerals

2. Water:
- ❍ Important for metabolic processes.
- ❍ **Prevent dehydration** of the body.

2 HUMAN DIGESTIVE SYSTEM

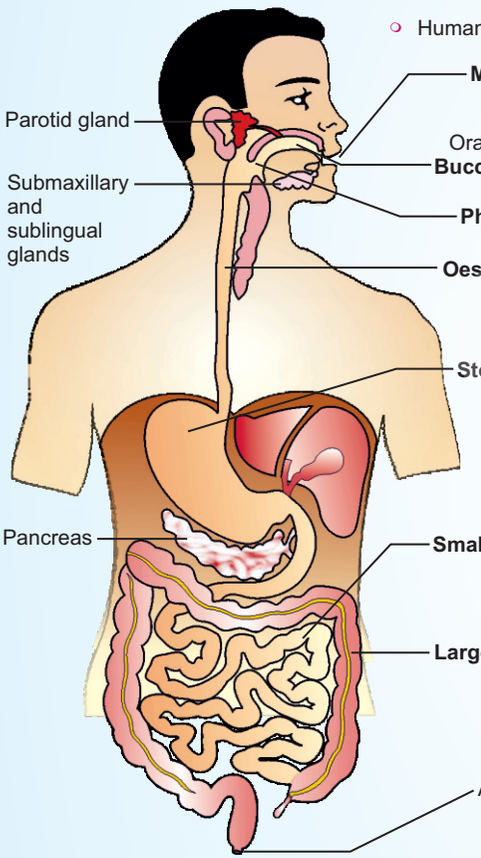


Fig.: Human digestive system

❍ Human digestive system consists of
- Alimentary canal
- Digestive glands/Associated glands

Mouth – Leads to **Oral cavity/ Buccal cavity**

❍ Has
- Teeth
- Tongue
  - • **Muscular** organ, attached to the floor of oral cavity by the **frenulum**
  - • Upper surface of the tongue has small projections called **papillae**. Some papillae have **taste buds**.

Pharynx
- ❍ Common passage for food and air

Oesophagus
- ❍ Thin, long tube
- ❍ Passes through neck, thorax and diaphragm

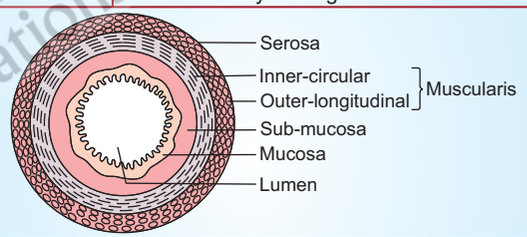
Stomach
- ❍ **J-shaped bag** in upper left side of abdominal cavity
- • 4 regions
  - **Cardiac** – Oesophagus opens here
  - **Fundic**
  - **Body** – Main central region
  - **Pyloric** – Opens into small intestine

Small intestine
- ❍ 3 regions
  - **Duodenum** – **'C'-shaped**
  - **Jejunum** – Long coiled part
  - **Ileum** – Highly coiled, opens into large intestine

Large intestine
- ❍ 3 regions
  - **Caecum** – Blind sac, host symbiotic microbes
    - • **Vermiform appendix:** **Vestigial** organ, finger-like tubular projection
  - **Colon**
    - Ascending
    - Transverse
    - Descending
    - **Sigmoid**
  - **Rectum**

3 HISTOLOGY OF GUT

Layers	Typical
❍ Serosa	❍ Outermost layer, made up to **thin mesothelium** (epithelium of visceral organs) with some connective tissues.
❍ Muscularis	❍ Inner – Circular muscles ❍ Outer – Longitudinal muscles
❍ Sub-mucosa	❍ **Loose connective tissue** with nerve, blood and lymph vessels.
❍ Mucosa	❍ Innermost layer lining the lumen



Modifications
- ❍ Stomach
  - ❍ **Oblique muscle** layer is present
  - ❍ Irregular folds of mucosa called **Rugae**
- ❍ Small intestine
  - ❍ Finger like foldings of mucosa called **villi**
  - ❍ Cells lining villi produce microscopic projections called **microvilli** giving **brush border appearance**

❍ **Villi, microvilli, rugae** – **Increase surface area** for absorption ❍ Villi are supplied with blood capillaries and **lacteals (Lymph vessel)** ❍ Gastric glands, goblet cells and crypts of Lieberkuhn – Present in mucosa ❍ **Brunner's gland** – Present in **sub-mucosa** ❍ The muscular activities of different parts of alimentary canal can be moderated by neural mechanisms, both local and through CNS.

❍ **Epiglottis** prevents the entry of food into the **glottis** (opening of trachea/wind pipe) during swallowing. ❍ **Sphincters are muscular structures** that regulate the flow of partially digested food in the alimentary canal.

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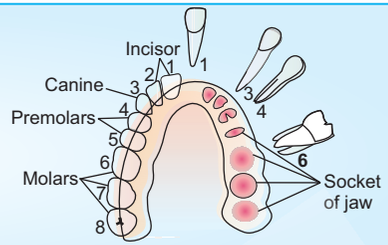
4 TEETH

- **Dentition:**
  - **Thecodont** – Each tooth is embedded in socket of jaw bone
  - **Heterodont** – Different types: Incisor (I), Canine (C), Premolar (PM), Molar (M)
  - **Diphyodont** – 2 sets of teeth during life
    - A set of **temporary/milk/deciduous** teeth which are replaced by a set of **permanent/adult teeth**
- **Dental formula** = $\frac{\text{Teeth in each half of upper jaw}}{\text{Teeth in each half of lower jaw}} = \begin{bmatrix} \text{I C PM M} \\ \frac{2\ 1\ 2\ 3}{2\ 1\ 2\ 3} \end{bmatrix} \times 2 = 32$

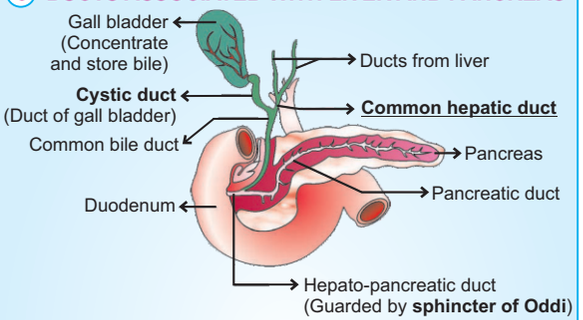


- **Enamel** – Hard chewing surface, helps in mastication of food.

5 DIGESTIVE GLANDS

Glands	Location	pH	Secretion	Contents	Function
Salivary Glands 1 Pair – Parotids 1 Pair – Submaxillary/ Submandibular 1 Pair – Sublinguals	Outside buccal cavity Cheek Lower jaw Below tongue	6.8	Saliva/ salivary juice into oral cavity	Mucus Electrolytes-Na^+, K^+, Cl^-, HCO_3^- Lysozymes Salivary amylase	Lubrication and adhering of masticated food into **bolus** Antibacterial agent, prevent infections Carbohydrate splitting enzyme
Gastric glands • Mucus neck cells • Peptic/chief cells • Parietal/oxyntic cells	Mucosa of stomach	1.8	Gastric juice in stomach	Mucus Pepsinogen (Active form) Prorennin (Active form) (infants) Lipase HCl Intrinsic factor	Lubrication and protection of mucosal epithelium from excoriation by HCl Protein digestion Digestion of milk proteins Fat digestion Acidic pH, activation of gastric proenzymes Absorption of vitamin B_{12}
Liver (Largest gland) 1.2-1.5 kg	Right side of abdomen below diaphragm	>7	Bile released into duodenum	Bile salt Bile pigments Cholesterol Phospholipids	Emulsification of fats Bilirubin and biliverdin • Bile activates lipases
Pancreas (Heterocrine gland)	Between limbs of duodenum	>7	Pancreatic juice released into duodenum	Trypsinogen, Chymotrypsinogen, Procarboxypeptidase (Active form) Amylase Lipases Nucleases	Protein digestion Carbohydrate digestion Fat digestion Nucleic acid digestion
Intestinal glands • Brunner's gland (no enzyme) • Crypts of Lieberkuhn	Sub mucosa of duodenum Mucosa of small intestine between bases of villi	7.8	**Intestinal juice/ Succus entericus**	Mucus Brush border enzymes • Disaccharidases • Dipeptidases • Lipases • Nuleosidases **Enterokinase**	Lubricate and protect intestinal mucosa from acid and provide alkaline medium for enzymatic activities Carbohydrate digestion Protein digestion Fat digestion Nucleosides digestion Activates trypsinogen into trypsin which in turn activates other enzymes in the pancreatic juice

6 DUCTS ASSOCIATED WITH LIVER AND PANCREAS



- Pancreas
  - **Exocrine** part secrete **alkaline** pancreatic juice containing **enzymes**
  - **Endocrine** part secrete **hormones**, insulin and glucagon

Schematic flow of digestive juices

Liver (hepatic cells) → Bile → Hepatic ducts → Common hepatic duct

Pancreatic duct → Cystic duct

Duodenum ← Hepato-pancreatic duct ← Common bile duct

Sphincter of Oddi

- **Hepatic lobules** are **structural and functional** unit of liver.
- Each lobule is covered by a thin connective tissue sheath called **Glisson's capsule**.
- Hepatic cells are arranged as cords in hepatic lobule.

- **Control of activities of gastro intestinal tract**
  - Saliva secretion – Stimulated by sight, smell and/or presence of food in oral cavity
  - Gastric and intestinal secretion – **Local hormones** produced by gastric and intestinal mucosa
    - Neural mechanisms – local and via CNS

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7 DIGESTION OF FOOD

- Various types of movements in alimentary canal (e.g. peristalsis) are generated by muscularis layer that helps in a thorough mixing up of the food with various secretions and thereby facilitate digestion.
- **Bolus** passes down into oesophagus by **swallowing/deglutition**.
- Complex food substances $\xrightarrow[\text{Biochemical process}]{\text{Mechanical process}}$ simple absorbable forms.

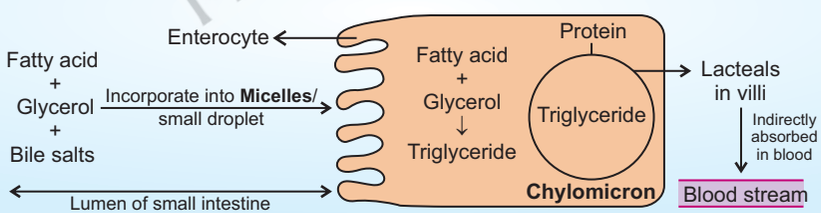
Juice	Site of Digestion	Carbohydrates	Proteins	Fats	Nucleic Acids
Saliva	Buccal cavity	(30%) Starch $\xrightarrow{\text{Salivary amylase}}$ Maltose	—	—	—
Gastric Juice	Stomach (stores food for 4-5 hrs.)	—	Pepsinogen $\xrightarrow{\text{HCl}}$ Pepsin Proteins $\rightarrow$ Peptones (peptides) + proteoses Milk protein $\xrightarrow[\text{Infants}]{\text{Rennin}}$ Peptones + proteoses	Lipase minor role	—
Bile	Intestine	—	—	Emulsification of fats *i.e.* Fats $\rightarrow$ micelles Activates lipases	—
Pancreatic juice	Intestine	Polysaccharides (Starch) $\xrightarrow{\text{Pancreatic amylase}}$ Disaccharides	Trypsinogen $\xrightarrow{\text{Enterokinase}}$ Trypsin Chymotrypsinogen $\rightarrow$ Chymotrypsin Procarboxypeptidase $\rightarrow$ Carboxypeptidase Proteins, Peptones, Proteoses $\rightarrow$ Dipeptides	Fats $\xrightarrow{\text{Lipases}}$ Diglycerides + Monoglycerides	Nucleic acids $\xrightarrow{\text{Nucleases}}$ Nucleotides
Succus entericus	Intestine	Maltose $\xrightarrow{\text{Maltase}}$ 2 Glucose Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose Sucrose $\xrightarrow{\text{Sucrase}}$ Glucose + Fructose	Dipeptides $\xrightarrow{\text{Dipeptidases}}$ Amino acids	Monoglycerides + Diglycerides $\xrightarrow{\text{Lipases}}$ Fatty acids + Glycerol	Nucleotides $\xrightarrow{\text{Nucleotidases}}$ Nucleosides $\xrightarrow{\text{Nucleosidases}}$ Sugars + Nitrogen bases

- Food in stomach mixes with acidic gastric juice by churning movements and is called **chyme**.
- Breakdown of biomacromolecules into its simplest form occurs in the duodenum.

8 ABSORPTION OF DIGESTED PRODUCTS

Method	Mechanism	Examples	
Passive: (Along concentration gradient)	Simple diffusion Facilitated transport Osmosis	Glucose, amino acids, Cl^- ions Glucose, amino acids Water	Directly absorbed into blood
Active: (Against concentration gradient) by utilising energy		Glucose, amino acids, Na^+ ions	

- **Absorption** is the process by which the end products of digestion (in the form of small units) pass through intestinal mucosa into the blood or lymph.
- The digested food is absorbed into the body through the epithelial lining of the intestinal villi of jejunum and ileum.



Summary of different substances absorbed in different parts of alimentary canal

Mouth and lower side of tongue		Certain drugs
Stomach		Simple sugars, alcohol, water
Small intestine	Lymph	Fatty acids, glycerol
	Blood	Glucose, fructose, amino acids
Large intestine		Water, drugs, some minerals

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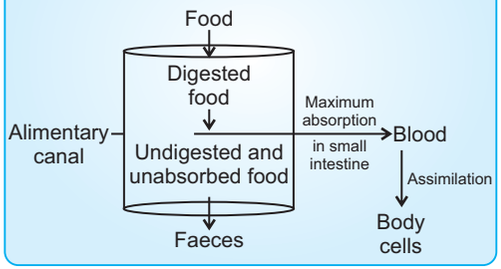
9 ASSIMILATION

- The digested end products formed in duodenum are absorbed and finally reach the tissues which utilise them for their activities. This process is called **Assimilation**.



10 ROLE OF LARGE INTESTINE

- **No significant digestive** activity occurs here.
- **Site for** — **Absorption** of water, minerals, certain drugs; **Secretion** of mucus, to adhere waste and for lubrication
- Solid faeces initiate neural reflex, causing urge for its removal.
- Undigested, unabsorbed substances enters caecum through **ileo-caecal valve** and the wastes solidified into **coherent faeces** which is temporarily stored in rectum till defaecation.
- Egestion of faeces to outside through anal opening is **defaecation**. It's a **voluntary process** and is carried by a **mass peristaltic movement**.

11 PROTEIN ENERGY MALNUTRITION (PEM)

- Dietary deficiencies of proteins and total food calories are widespread in children of underdeveloped countries.
- It may affect large sections of the population during drought, famine and political turmoil.

Parameters	Kwashiorkor	Marasmus
Dietary deficiency	Proteins	Proteins and calories
Age	Child more than 1 year	Infants less than 1 year
Reason	Replacement of mother's milk by high calorie, low protein diet	Replacement of mother's milk too early by other foods or mother has second pregnancy when older infant is too young
Characteristics	**Extensive oedema i.e. swelling of body parts** Wasting of muscles, thinning of limbs	**Extensive emaciation of body,** Skin is dry, thin and wrinkled, thinning of limbs

In PEM — Growth rate and body weight decline; Growth and development of brain and mental faculties are impaired.

12 ENERGY VALUES

Gross Calorific Value	Physiological Value
Amount of heat liberated from complete combustion of 1 gm of food in bomb calorimeter (metal chamber filled with O_2)	Actual amount of energy released on combustion of 1 g of food in body
• Carbohydrates - 4.1 K cal/g	4.0 K cal/g
• Proteins - 5.65 K cal/g	4.0 K cal/g
• Fats - 9.45 K cal/g	9.0 K cal/g

- 1 kilo calorie is the amount of energy required to raise the temperature of 1 kg of water by 1°C
- Energy requirements of animals, and the energy content of food expressed in terms of heat energy, (calorie (cal) or joule (J)). Since this value is tiny amount of energy, physiologists commonly use kilocalorie (kcal) or kilo joule (kJ).

13 DISORDERS OF DIGESTIVE SYSTEM

Disease/Problem	Cause and Symptoms
Inflammation of intestinal tract	Most commonly due to bacterial and viral infections. Can be due to parasites like roundworm, tapeworm, threadworm, hookworm, pin worm etc.
Jaundice	**Liver** affected Skin and eyes turn yellow due to **deposit of bile pigments**.
Vomiting	**Ejection of stomach content**, feeling of nausea precedes vomiting. It's a reflex action controlled by **vomit centre**, **medulla**.
Diarrhoea	Abnormal frequency of bowel movement and Increased liquidity of faecal discharge, reduces food absorption.
Constipation	Faeces are **retained within the colon** as bowel movement occurs irregularly.
Indigestion	Food **not digested properly**, feeling of fullness. Can be due to inadequate enzyme secretion, anxiety, food poisoning, over eating and spicy food.

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Sharpen Your Understanding

1. The number of molars, premolars, canines and incisors in upper jaw of adult humans are respectively. [NCERT Pg. 258]
   (1) 2 1 2 3 (2) 6 4 2 4
   (3) 4 2 4 6 (4) 2 1 2 2
2. In the basic histology of human gut, muscular coat of stomach is having an additional layer of which muscle fibres? [NCERT Pg. 259]
   (1) Circular muscle fibres
   (2) Longitudinal muscle fibres
   (3) Oblique muscle fibres
   (4) Skeletal muscle fibres
3. Most of the digestive glands are present in the mucosa **except** [NCERT Pg. 262]
   (1) Goblet cells
   (2) Crypts of Lieberkuhn
   (3) Brunner's gland
   (4) Gastric gland
4. Find the **incorrect** statement [NCERT Pg. 258, 259]
   (1) Diphyodont is a type of dentition where temporary teeth are replaced by permanent teeth
   (2) Some of the papillae on tongue bear taste buds
   (3) Cardiac sphincter regulates the opening of stomach into duodenum
   (4) Caecum hosts some symbiotic micro-organisms

NCERT Based MCQs

5. Food thoroughly mixed with acidic gastric juice of the stomach is called [NCERT Pg. 261]
   (1) Chyle (2) Bolus
   (3) Chyme (4) Faeces
6. Digestive juices that enters into the duodenum through sphincter of Oddi are
   (a) Gastric juice
   (b) Bile juice
   (c) Pancreatic juice
   (d) Succus entericus [NCERT Pg. 262]
   (1) Only (c) (2) Only (b)
   (3) Both (b) and (c) (4) Both (c) and (d)
7. Choose the symptom which occurs in kwashiorkor but absent in marasmus [NCERT Pg. 266]
   (1) Growth inhibition
   (2) Wasting of muscles
   (3) Oedema of limbs
   (4) Depletion of subcutaneous layer of fat
8. Which layer of stomach forms irregular folds to increase surface area for absorption? [NCERT Pg. 259]
   (1) Submucosa (2) Mucosa
   (3) Muscular layer (4) Serosa
9. Gross calorific value of protein is [NCERT Pg. 264]
   (1) 5.65 k cal/g (2) 4.0 k cal/g
   (3) 4.1 k cal/g (4) 9.1 k cal/g
10. Which of the following are **not** absorbed into the lymph vessels from intestinal epithelial cells? [NCERT Pg. 265]
    (a) Chylomicrons
    (b) Amino acids
    (c) Monosaccharides
    (d) Protein coated fat globule
    (1) (b) and (c) (2) (a) and (b)
    (3) (c) and (d) (4) (a) only
11. Nucleases like DNase and RNase are found in [NCERT Pg.263]
    (1) Gastric juice (2) Intestinal juice
    (3) Pancreatic juice (4) Saliva
12. The chemical process of digestion is initiated in [NCERT Pg. 261]
    (1) Gastric cavity (2) Oral cavity
    (3) Small intestine (4) Oesophagus
13. Factor essential for absorption of vitamin B_{12} is produced by [NCERT Pg. 262]
    (1) Mucus neck cells
    (2) Peptic cells
    (3) Parietal cells
    (4) Chief cells

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14. Read the following statements and choose the **correct** answer.

A – Among the different regions of small intestine, duodenum is the main site of digestion.

R – It is the longest part of small intestine with maximum number of villi.

[NCERT Pg. 263]

(1) A and R, both are correct

(2) A is correct and R is incorrect

(3) Both A and R are incorrect

(4) R is the correct reason for A

15. One amongst the following is **not** associated with pancreatic juice? [NCERT Pg. 263]

(1) Procarboxypeptidase

(2) Trypsinogen

(3) Nucleotidase

(4) Amylase

16. Enterokinase which activates trypsinogen is secreted by [NCERT Pg. 262]

(1) Pancreas

(2) Liver

(3) Stomach

(4) Intestinal mucosa

17. When the food is not properly digested and leads to a feeling of fullness, it is called [NCERT Pg. 265]

(1) Heartburn (2) Indigestion

(3) Ulcer (4) Constipation

18. Which of the following is **not** a component of bile? [NCERT Pg. 262]

(1) Bilirubin

(2) Bile salts

(3) Lipase

(4) Cholesterol

19. Active absorption of sodium through mucosal cells are coupled with movement of [NCERT Pg. 264]

(a) Glucose

(b) Amino acids

(c) Fatty acids

(d) Glycogen

(1) (a) and (d) (2) (b) and (d)

(3) (b) and (c) (4) (a) and (b)

20. Following are some structures associated with alimentary canal of man

(a) Rugae (b) Ileo-caecal valve

(c) Pyloric sphincter (d) Villi

Which of the given structures increases absorptive surface area? [NCERT Pg. 259]

(1) (d) only (2) (a) and (d)

(3) (a), (b) and (c) (4) (c) and (d)

Thinking in Context

1. Tooth embedded in a socket of jaw bone is called _____. [NCERT Pg. 257]
2. Structural and functional unit of liver is called _____. [NCERT Pg. 260]
3. Initial activation of trypsinogen occurs by _____. [NCERT Pg. 262]
4. The hard chewing surface of teeth that directly comes in contact with food and helps in mastication of food is _____. [NCERT Pg. 258]
5. Pepsin and trypsin are protein digesting enzymes. Pepsin acts in __X__ medium and trypsin in __Y__ medium. [NCERT Pg. 263]
6. Conversion of complex food substances into simple absorbable forms occurs by _____ and _____ methods. [NCERT Pg. 257]
7. Fill the blanks with **correct** representation for a, b, c and d.

- Sucrose $\xrightarrow{a}$ Glucose + $\underline{\quad b \quad}$
- Lactose $\xrightarrow{c}$ Glucose + $\underline{\quad d \quad}$

[NCERT Pg. 263]

8. __X__ pairs of salivary glands are present __Y__ the buccal cavity and release their secretions into the __Z__ . [NCERT Pg. 260]
9. Thin connective tissue sheath around hepatic lobule is called _____. [NCERT Pg. 260]

10. The egestion of faeces to the outside through the anal opening is called _____. [NCERT Pg. 265]
11. Breakdown of fats into very small micelles is termed as _____. [NCERT Pg. 262]
12. Principal organ for absorption of nutrients and water is _____. [NCERT Pg. 265]
13. _____ part of gut allows passage of food and air through it. [NCERT Pg. 258]
14. Back flow of faecal matter from large intestine to small intestine is prevented by _____. [NCERT Pg. 264]
15. Gastric and intestinal secretions are stimulated by _____. [NCERT Pg. 264]
16. Yellowing of eyes in Jaundice is due to deposit of _____. [NCERT Pg. 265]
17. Deficiency of food and calories together in infants less than 1 year of age can lead to _____. [NCERT Pg. 266]
18. _____ protect mucosal epithelium from excoriation by concentrated HCl. [NCERT Pg. 262]
19. Chylomicrons are _____. [NCERT Pg. 265]
20. Reflex action of vomiting is controlled by _____ in CNS. [NCERT Pg. 265]

❑ ❑ ❑

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Breathing and Exchange of Gases

5 Chapter

1 BREATHING/RESPIRATION

Atmospheric oxygen ⇌ (Exchange) CO_2 produced by cells

2 RESPIRATORY ORGANS

- Based on — Habitats / Levels of organisation

Organism	Mechanism
Sponges, coelenterates flatworms	Simple diffusion
Earthworm	Moist skin
Insects	Tracheal tubes
Aquatic arthropods, molluscs, fish	Branchial/Gills
Amphibians, reptiles, aves, mammals	Pulmonary/lungs

Amphibians show cutaneous respiration all the time

3 OUTLOOK OF HUMAN RESPIRATORY SYSTEM

Epiglottis (Elastic cartilage that covers glottis during swallowing)

Nostrils → Nasal chamber → Pharynx → Larynx → Trachea → Bronchus → Primary → Secondary → Tertiary → Initial bronchiole → Terminal bronchiole → Alveoli

In close contact with thoracic lining

2 pleural membranes: Outer, Inner

In contact with lung surface

Pleural fluid reduces friction on lung surface

Inside Lungs

- Common passage for air/food
- Voice box
- Divides at 5th thoracic vertebra
- Till here supported by incomplete cartilaginous rings
- Vascular bags with thin, irregular walls

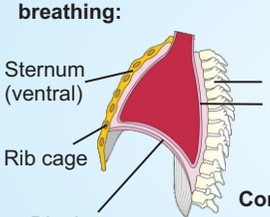
Conducting zone / Respiratory zone

Functions

- **Conducting zone** — Humidification of air; Transport of air; Traps dust present in inhaled air; Bring air to body temperature
- **Respiratory zone** — Exchange of gases

4 MECHANISM OF BREATHING

- Lungs, enclosed in an anatomically air tight thoracic chamber: essential for breathing as we cannot alter pulmonary volumes directly.
- Movement of air follows the pressure gradient
- **Specialised set of structures involved in breathing:**



Contraction : Changes volume in dorso-ventral axis

Contraction : Changes volume in antero-posterior axis

Additional muscles involved in expiration : Abdominal muscles

Normal rate of breathing 12-16 times/minute in adult human

Involve

	Inspiration	Expiration
Intrapulmonary pressure	Low	High
Pressure in the lungs w.r.t. atmosphere	–ve	+ve
Shape of diaphragm	Flat	Dome-shaped

- **Exchange of gases is based on :**
  - Concentration gradient
  - Thickness of membrane
  - Solubility of gases - CO_2 is 20-25% more soluble than O_2
  - Any factor that affects diffusion rate

Diffusion membrane comprises of 3 layers: thin squamous epithelium of alveoli, endothelium of capillaries and basement substance in between

5 EXCHANGE OF GASES

- **Partial pressure drives respiration**
- **Site of exchange**
  - Alveoli (Primary)
  - Between blood and tissues
- **Partial pressure:**
  - Pressure contributed by an individual gas in a mixture of gases

Respiration steps	Atmosphere	Partial pressure of gases (mm Hg) O_2	CO_2
	CO_2 O_2		
1. Breathing/pulmonary ventilation		159	0.3
2. Diffusion across alveolar membrane (less than 1 mm thick)		104	40
3. Transport of gases by blood		95	45
4. Diffusion b/w blood and tissues			
5. Cellular respiration	CO_2 O_2	40	45

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6 RESPIRATORY VOLUME AND CAPACITIES

- **Instrument** - Spirometer
- **Significance** - Clinical assessment of pulmonary functions

Minute volume : TV × respiratory rate i.e., 500 × 12 = 6000-8000 ml
Pulmonary capacity : Addition of various respiratory volumes e.g., FRC = RV + ERV

Standard volumes

1. Tidal volume/air inhaled or exhaled per breath
2. Inspiratory reserve volume/forceful inhalation
3. Expiratory reserve volume/forceful exhalation
4. Residual volume/air left in lungs after forceful exhalation

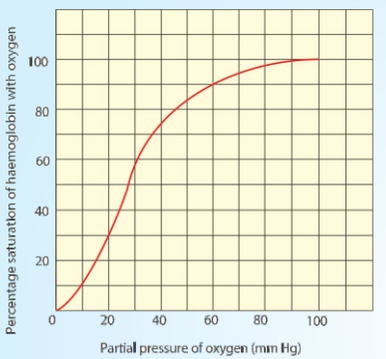
EC

Value in ml	Standard capacities
TV - 500	IC, VC, TLC
IRV - 2500-3000	IC, VC, TLC
ERV - 1000-1100	FRC, VC, TLC
RV - 1100-1200	FRC, TLC

7 TRANSPORT OF GASES

Lungs $\xrightarrow{O_2}$ Blood $\xrightarrow{CO_2}$ Tissue

Oxygen dissociation curve



Oxygen

- 5 ml of O_2 is delivered to the tissues by 100 ml of oxygenated blood
- 3% dissolved in plasma
- 97% as **oxyhaemoglobin**
- Binding of O_2 with Hb is primarily related to pO_2

Carbon dioxide

- 4 ml of CO_2 is delivered to alveoli by 100 ml of deoxygenated blood
- 7% dissolved in plasma
- 20-25% as **carbamino Hb**
- Binding of CO_2 with Hb is related to pCO_2 as well as pO_2

$Hb + O_2 \rightleftharpoons$ Oxyhaemoglobin

$Hb + CO_2 \rightleftharpoons$ Carbamino-haemoglobin

Parameter	Association	Dissociation	Association	Dissociation
High pO_2	↑	↓	↓	↑
Low pCO_2	↓	↑	↑	↓
High H^+	↓	↑	↑	↓
High temperature	↓	↑	↑	↓
Location	Lungs (Alveoli)	Tissue	Tissue	Lungs (Alveoli)

- Each Hb. molecule carries or binds 4 oxygen molecules in a **reversible** manner.
- Oxygen dissociation curve obtained is **sigmoid**
- Maximum (70%) CO_2 is transported as bicarbonates facilitated by enzyme **carbonic anhydrase**, which exists more in RBCs and minute quantities in plasma

$$CO_2 + H_2O \xrightleftharpoons{\text{C. anhydrase}} H_2CO_3 \xrightleftharpoons{\text{C. anhydrase}} HCO_3^- + H^+$$

8 REGULATION OF RESPIRATION

- Humans have significant ability to maintain and moderate the respiratory rhythm to suit the demands of the body tissues

Regions involved	Pneumotaxic center	Chemosensitive Area	Aortic receptors	Carotid receptors
Location	Pons	Medulla oblongata	Aortic arch	Carotid artery
	Reduces duration of inspiration	Respiratory adjustments		
Sensitive to		$\uparrow pCO_2, \uparrow H^+$		

Influence → **Medulla oblongata**
Primary respiratory rhythm center

The role of oxygen in the regulation of respiratory rhythm is quite insignificant.

9 DISORDERS

Diseases	Impact zone	Characteristic(s)
Asthma	Inflammation of bronchi, bronchioles	Wheezing sound
Emphysema	Alveolar wall damage in chronic cigarette smokers	Respiratory surface decreased
Occupational respiratory disorder	Lungs	Fibrosis, lungs damage

Masks give protection to workers engaged in industries that are involved in dust producing, grinding and stone breaking.

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Sharpen Your Understanding

1. Among vertebrates which of the following do **not** exclusively respire through lungs? [NCERT Pg. 268]

(1) Birds (2) Mammals

(3) Reptiles (4) Amphibians

2. How many of the given structures in the box below are surrounded by incomplete cartilaginous rings? [NCERT Pg. 269]

Trachea, Pharynx, Secondary bronchus, Primary bronchiole, Alveoli

(1) One

(2) Four

(3) Three

(4) Two

3. Normal inspiration involves contraction of which of the given muscles? [NCERT Pg. 270]

a. Diaphragm

b. External intercostals

c. Internal intercostals

d. Abdominals

(1) a, c

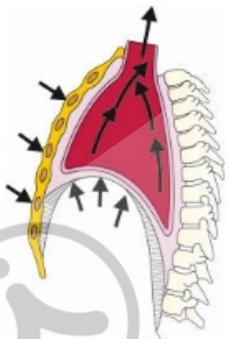
(2) a, d

(3) b, d

(4) a, b

NCERT Based MCQs

4. Given below is the diagrammatic representation, explaining mechanism of breathing.



Choose the **correct** option w.r.t. given diagram. [NCERT Pg. 271]

(1) Diaphragm becomes dome shaped due to contraction of its muscles and decreases the volume of thoracic cavity

(2) Volume of thoracic cavity decreases due to contraction of external intercostal muscles

(3) Diaphragm is relaxed and arched upwards which decreases the volume of thoracic cavity

(4) Contraction of external intercostal muscles shifts the ribs inwards and downwards

5. Diffusion membrane involves all the following layers **except** [NCERT Pg. 273]

(1) Squamous epithelium of alveoli

(2) Endothelium of alveolar capillaries

(3) Endothelium of systemic capillaries

(4) Basement substance

6. The part starting from external nostrils upto terminal bronchioles is **not** associated with [NCERT Pg. 270]

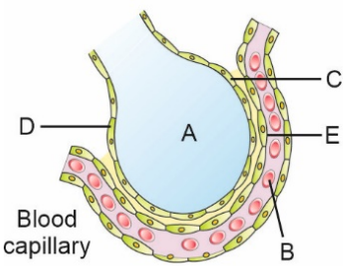
(1) Gaseous exchange

(2) Clearing air from foreign particles

(3) Humidification of air

(4) Bringing air to body temperature

7. Following diagram represents a section of an alveolus with a pulmonary capillary [NCERT Pg. 273]



The diffusion membrane includes :

Cellular layer/s	Non cellular layer/s
(1) A, C, D	–
(2) D, E	C
(3) D, E, C	–
(4) A	C, D

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8. How much amount of air is inspired or expired per minute during normal breathing by an adult man? [NCERT Pg. 271]
(1) 500-800 ml (2) 1000-1100 ml
(3) 6000-8000 ml (4) 2500-3000 ml

9. Vital capacity is represented by all **except** [NCERT Pg. 272]
(1) TV + ERV + IRV (2) EC + IRV
(3) IC + ERV (4) RV + TLC

10. All the following factors favour the formation of oxyhaemoglobin **except** [NCERT Pg. 274]
(1) High pO_2
(2) Low pCO_2
(3) High H^+ ion concentration
(4) Normal body temperature

11. How much amount of oxygen is delivered by 100 ml of oxygenated blood to the body tissues under normal physiological conditions? [NCERT Pg. 274]
(1) 20 ml (2) 5 ml
(3) 15 ml (4) 10 ml

12. Which of the following is a common passage for air and food? [NCERT Pg. 269]
(1) Larynx
(2) Trachea
(3) Pharynx
(4) Nostrils

13. The partial pressure of oxygen in atmosphere air at sea level is [NCERT Pg. 272]
(1) 159 mmHg (2) 116 mm Hg
(3) 95 mm Hg (4) 40 mm Hg

14. Which of the given factor favours the dissociation of CO_2 from carbamino haemoglobin? [NCERT Pg. 274]
(1) High pCO_2, low pO_2 - In tissue
(2) Low pCO_2, high pO_2 - In alveoli
(3) Low pO_2, high pCO_2 - In alveoli
(4) High pO_2, high pCO_2 - In alveoli

15. The enzyme carbonic anhydrase facilitates which of the given reactions? [NCERT Pg. 275]
a. $CO_2 + H_2O \longrightarrow H_2CO_3$
b. $H_2CO_3 \longrightarrow HCO_3^- + H^+$
c. $H_2CO_3 \longrightarrow CO_2 + H_2O$
d. $HCO_3^- + H^+ \longrightarrow H_2CO_3$
(1) a, d only (2) b, c only
(3) a, c only (4) a, b, c, d

16. Neural signals from the pneumotaxic centre can alter the respiratory rate by [NCERT Pg. 275]
(1) Increasing the duration of expiration
(2) Increasing the duration of inspiration
(3) Reducing the duration of inspiration
(4) Altering the pCO_2 and pO_2 in blood

17. Thoracic chamber is formed [NCERT Pg. 276]
a. Dorsally by vertebral column
b. Ventrally by sternum
c. Laterally by ribs
d. Lower side by diaphragm
(1) a, c only (2) a, b, c only
(3) b, c, d only (4) a, b, c, d

18. Which of the following disease in characterised by proliferation of fibrous connective tissue in upper part of lungs? [NCERT Pg. 276]
(1) Asthma
(2) Emphysema
(3) Bronchitis
(4) Occupational respiratory disease

19. Select the **incorrect** statement [NCERT Pg. 274, 275]
(1) Concentration of CO_2 in veins and oxygen in arteries regulate the respiratory rhythms in humans
(2) In emphysema, there is damage to the alveolar walls and decrease in total respiratory surface area
(3) Carbamino-haemoglobin results from association of CO_2 with haemoglobin
(4) Human beings have a significant ability to maintain and moderate the respiratory rhythms

20. At what pO_2, does 50% of haemoglobin get saturated under normal conditions in humans? [NCERT Pg. 274]
(1) 10-15 mm Hg
(2) 27-30 mmHg
(3) 37-40 mm Hg
(4) 45-50 mm Hg

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Thinking in Context

1. Mechanism of breathing varies among different animals depending mainly on their _____ and _____. [NCERT Pg. 268]
2. During swallowing, entry of food in the respiratory tract is prevented by _____ flap called _____. [NCERT Pg. 269]
3. In humans, trachea is a straight tube extending upto mid thoracic cavity and divide at level of _____ vertebra. [NCERT Pg. 269]
4. Contraction of diaphragm increases volume of thoracic chamber along _____ axis. [NCERT Pg. 270]
5. During inhalation, there is an _____ in pulmonary volume and the intrapulmonary pressure is _____ than the atmospheric pressure. [NCERT Pg. 271]
6. The volumes of air involved in breathing movement can be measured by using instrument named as _____. [NCERT Pg. 271]
7. Solubility of CO_2 is _____ times higher than that of oxygen. [NCERT Pg. 273]
8. pCO_2 in dexoygenated blood is _____ and in oxygenated blood is _____ respectively. [NCERT Pg. 273]
9. The volume of air left in the lungs after a normal expiration is called _____. [NCERT Pg. 272]
10. Primary site for exchange of gases is _____. [NCERT Pg. 272]
11. Oxygen binds with haemoglobin in a _____ manner to form oxyhaemoglobin. [NCERT Pg. 274]
12. _____ curve is obtained when percentage saturation of haemoglobin with oxygen is plotted against pO_2. [NCERT Pg. 274]
13. On an average, a healthy human breathes _____ times/minute. [NCERT Pg. 274]
14. Each haemogobin molecule can carry a maximum of _____ atoms of oxygen. [NCERT Pg. 274]
15. Maximum amount of CO_2 is transported in the form of _____ [NCERT Pg. 275]
16. Every 100 ml of deoxygenated blood can deliver approximately _____ ml of CO_2 to the alveoli. [NCERT Pg. 275]
17. Respiratory rhythm center in humans is located in _____ [NCERT Pg. 275]
18. Chemosensitive area, adjacent to the rhythm center is highly sensitive to _____ and _____. [NCERT Pg. 275, 276]
19. A chronic disorder in which alveolar walls are damaged and respiratory surface decreases is _____. [NCERT Pg. 275]
20. The role of _____ in the regulation of respiratory rhythm is quite insignificant in humans [NCERT Pg. 275]

❑ ❑ ❑

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Body Fluids and Circulation

Chapter 6

1 BLOOD VASCULAR SYSTEM

Constituents: Blood + Blood vessels + Heart

- Synthesised in Red bone marrow
- **Components:**

(A) Plasma (matrix, 55%)

- **Water:** 90-92%
- **Proteins:** 6-8%
  - Fibrinogens – Clotting
  - Albumins – Osmotic balance
  - Globulins –Defense
- **Minerals:** Na^+, Ca^{+2}, Mg^{+2}, HCO_3^-, Cl^-
- **Nutrients:** Glucose, amino acids, lipids

Functions performed:

- Transport of nutrients, O_2, glucose *etc*
- Removal of harmful substances

Medium of transport:

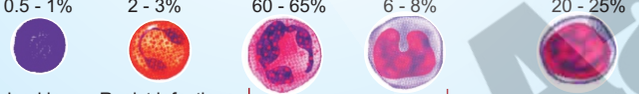
- **Water**
  - Sponges & coelenterates
- **Blood & lymph**
  - Humans

(B) Formed Elements (45%)

Parameter	RBCs/Erythrocytes	WBCs/ Leucocytes	Platelets/Thrombocytes
Number	5-5.5 million/mm^3	6000-8000//mm^3	1,500,00-3,500,00/mm^3
Colour	Red due to iron containing Hb (12-16 gm/100 ml)	Colourless	Colourless
Nucleus	Absent	Present	Absent
Life span	120 days	Generally short lived	Short lived
Function	Transport of gases	Defense	Coagulation of blood. If number drops, can lead to loss of blood from body

Types of WBCs

- **Granulocytes**
  - **Basophils** 0.5 - 1%
  - **Eosinophils** 2 - 3%
  - **Neutrophils** 60 - 65%
- **Agranulocytes**
  - **Monocytes** 6 - 8%
  - **Lymphocytes** 20 - 25%



- **% of total WBCs**
- **Shape of nucleus**
- **Function**
  - Basophils: Involved in inflammatory reactions
  - Eosinophils: Resist infections, associated with allergic reactions
  - Neutrophils, Monocytes: Phagocytic in action
  - Lymphocytes: Involved in immune response of body

- RBCs are biconcave and enucleated in most mammals
- Platelets are cell fragments of **megakaryocytes**
- Graveyard of RBCs - spleen
- Basophils secrete heparin, histamine, serotonin

2 BLOOD CLOTTING/ COAGULATION

- In response to injury/ trauma, clotting prevents loss of blood from body.
- **Events involved:**

Plasma – Clotting factors = Serum

Injured tissue / Platelets → Release chemicals → **(Cascade process)** → Formation of Thrombokinase (enzyme complex) → Prothrombin → Thrombins → Fibrinogens → Fibrins + entangled formed elements (Coagulam/reddish brown clot)

- Ca^{2+} ions play an important role in clotting
- **Clotting factors** in blood are in **inactive form**

4 BLOOD GROUPS

Based on: **ABO grouping** / **Rh grouping**

Parameter	Natural Antigen	Natural Antibodies
Definition	Chemicals that induce immune response	Proteins produced in response to antigens
Present	On RBC	In plasma
Type	A, B	Anti- A, B

Parameter	Rh+ve	Rh–ve
Rh factor Present	✓ on RBC	× ×

80% humans are Rh +ve

- Blood group and Rh factor compatibility of donor and recipient is done before transfusion to avoid clumping of RBCs

Blood Group	Antigens on RBCs	Antibodies in Plasma	Donor's Group
A	A	anti-B	A, O
B	B	anti-A	B, O
AB	A, B	nil	AB, A, B, O
O	nil	anti-A, B	O

Universal Donor
Universal Recipient

Rh^{-ve} person upon exposure to Rh^{+ve} blood will form Rh specific antibodies

Special case of Rh incompatibility

Mother Rh^{-ve} ← Foetus Rh^{+ve}

1^{st} **baby normal**, as during pregnancy, no mixing of blood due to separation by placenta

↓

During delivery, there are chances of mixing of blood

↓

Rh^{-ve} mother makes antibodies against Rh antigen

↓

Antibodies cross placenta in subsequent pregnancy

↓

Severe anemia and jaundice in baby

↓

Erythroblastosis foetalis

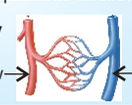
Administer anti Rh antibodies to the mother immediately after 1^{st} delivery, save baby

3 BLOOD VESSELS

Layers in wall:

Name	Position	Composition
Tunica externa	Outermost	Fibrous connective tissue & collagen fibres
Tunica media	Middle	Smooth muscle & elastic fibres
Tunica intima	Innermost	Squamous endothelium

	Artery	Vein
Tunica media	Thick	Thin
Lumen	Narrow →	← Wide



6 LYMPH (Tissue fluid)

- Colourless
- **Blood - (Larger proteins + most formed elements)**
- Rich in lymphocytes
- Carrier for nutrients, hormones and fats
- Lymphatic vessels drain interstitial fluid back to major veins

Lacteals are lymph vessels in intestinal villi to absorb fats

5 CIRCULATORY PATHWAYS

	Open	Closed
Sinuses	Present	Absent
Regulation of blood flow	Imprecise	Precise
Examples	Arthropods, molluscs	Annelids, chordates

Vertebrates	Auricle(s)	Ventricle(s)	Circulation
Fishes	1	1	Single
Amphibians, most reptiles	2	1	Incomplete
Crocodile, Aves Mammals	2	2	Double

Fishes pump deoxygenated blood to gills for oxygenation.

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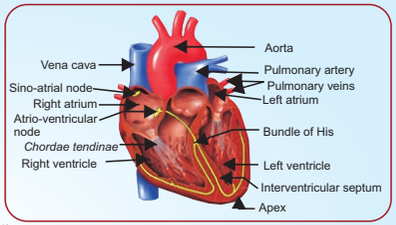
7 HUMAN CIRCULATORY SYSTEM

Heart

- Mesodermally derived organ present in between lungs, muscular, chambered, tilted to left
- Protected by double walled, membranous bag- **Pericardium** with **pericardial fluid**
- 4 chambers → 2 upper, smaller– Auricles; 2 lower, larger – Ventricles
- Septum
  - → Between auricles: Inter-atrial (thin, muscular)
  - → Between ventricles: Inter-ventricular (thick walled)
  - → Between auricle & ventricle: Auriculo-ventricular (thick fibrous)



- Cardiac valves
  - → Between right auricle & right ventricle – Tricuspid
  - → Between left auricle & left ventricle – Bicuspid/Mitral
  - → At base of pulmonary artery / At base of aorta – Semilunar

Valves are muscular flaps or cusps that allow unidirectional flow of blood and prevent its backward flow

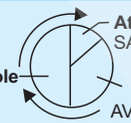
- Cardiac muscles
  - Contractile tissue
  - Nodal tissue **(Auto excitable)**
    - Sino-auricular node/ **(SA node/pacemaker)** – Right upper corner of right atrium
    - Atrioventricular node/ AV node – Left lower corner of right atrium
    - AV bundle – Interventricular septum
    - Purkinje fibres – Divides at apex of ventricle
- SAN – Maximum excitability – 70-75 action potentials/min

8 TYPES OF CIRCULATION

- **Double circulation**
  - **Pulmonary:** Right ventricle → Pulmonary artery → Lungs → Pulmonary veins → Left auricle
  - **Systemic:** Left ventricle → Aorta → Tissues → Vena cava → Right auricle
  - • No mixing of deoxygenated and oxygenated blood occurs
- **Hepatic portal circulation** – Digestive tract → Hepatic portal vein → Liver
- **Coronary circulation** – Blood flow to and from the cardiac musculature

9 CARDIAC CYCLE

- Sequential events in the heart which are cyclically repeated.
- Heart beat rate = 72 beats/min
- Duration of 1 heart beat = 0.8 sec.



(1) Joint diastole

Atrial systole (2) SAN generates action potentials

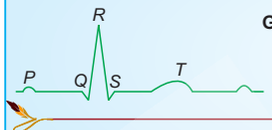
Ventricular systole (3) AV node, AV bundles, bundle of His transmit the action potential further

Events of 1 cardiac cycle

Location/Structure	Joint Diastole	Atrial Systole	Ventricular Systole
Auricle	Relax, filling	Contract, increase flow of blood into ventricles by 30%	Relax
Ventricle	Relax	Relax	Contract, throw out 70 ml of blood/ventricle – **Stroke volume**
Tri & Bicuspid valves	Open	Open	Closed, 1st heart sound **Lub**
Semilunar valves	Closed, 2nd heart sound **Dub**	Closed	Open

10 ELECTROCARDIOGRAPH (ECG)

- ECG is a graphical representation of electrical activities of heart during a cardiac cycle
- **Instrument** – Electrocardiograph
- **Graphical print** – Electrocardiogram
- For a standard ECG – 3 leads are connected to monitor heart activity – Right wrist, left wrist and left ankle



Graphical standards	Represent	Event associated
P wave	Depolarisation of atria	Contraction of atria
QRS complex	Depolarisation of ventricles	Contraction of ventricles
T wave	Repolarisation of ventricles	Relaxation of ventricles

- Number of QRS complexes in a given time period, determine the heart beat rate of an individual
- End of T-wave marks the end of systole
- Any deviation in ECG indicates a possible abnormality or disease *e.g.* ECG machine makes sound pip----pip---pee as patient goes into cardiac arrest.

11 REGULATION OF CARDIAC CYCLE

Activities of heart are regulated intrinsically *i.e* autoregulated as human heart is **myogenic**

Medulla oblongata can moderate ↓ Cardiac functions through ↓ Autonomic nervous system (ANS)

Parameter	Sympathetic	Parasympathetic
Heart beat rate	Increase	Decrease
Strength of ventricular contraction	Increase	Decrease
Cardiac output	Increase	Decrease

Hormones of adrenal medulla increase cardiac output

12 DISORDERS OF CIRCULATORY SYSTEM

Disease	Effects
Cardiac arrest	Heart stops beating
Heart failure	Heart is not pumping blood effectively enough to meet needs of body
Atherosclerosis/(CAD) Coronary artery disease	Deposit of Ca^{+2}, fats, cholesterol in blood vessels that makes arterial lumen narrower
High blood pressure	Repeated checks of blood pressure of an individual ≥ 140/90, leads to heart diseases and also affects vital organs like brain and kidneys.
Angina pectoris/ acute chest pain	Not enough oxygen is reaching heart muscles. It affects blood flow. Common in middle aged and elderly.
Heart attack	Heart muscle is suddenly damaged by an inadequate blood supply.

- Heart sounds (Lub & dub)can be heard by **Stethoscope** and have clinical diagnostic significance.
- **Cardiac output** = Stroke volume × Heart rate = 70 × 72 ≃ 5 litres
- Cardiac output of athletes is higher than a normal man

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Sharpen Your Understanding

1. A drop of each of the following is placed on different slides, which of the them will **not** coagulate? [NCERT Pg. 281]
   (1) Blood (2) Plasma
   (3) Serum (4) Lymph
2. The exchange of material between blood and interstitial fluid occurs only at the level of [NCERT Pg. 282]
   (1) Arteries (2) Veins
   (3) Capillaries (4) Arterioles
3. If the parasympathetic influence on heart is removed, heart will [NCERT Pg. 287]
   (1) Beat slowly (2) Beat faster
   (3) Show no change (4) Stop beating
4. Arrange the conducting regions of the heart in a sequence from starting with [NCERT Pg. 284]
   (a) AV node (b) AV bundle
   (c) SAN (d) Purkinje fibres
   (1) c – b – a – d (2) c – a – b – d
   (3) a – d – c – b (4) a – b – d – c
5. Every 100 ml of human blood contains approximately how much amount of haemoglobin? [NCERT Pg. 279]
   (1) 8-12 gm (2) 12-16 gm
   (3) 12-16 mg (4) 18-12 mg
6. Which vascular connection connects digestive tract and liver? [NCERT Pg. 287]
   (1) Coronary circulation
   (2) Renal portal system
   (3) Hepatic portal system
   (4) Systemic circulation

NCERT Based MCQs

7. First heart sound is due to [NCERT Pg. 285]
   (1) Opening of tri and bi-cuspid valves
   (2) Closure of tri and bi-cuspid valves
   (3) Opening of semilunar valves
   (4) Closure of semilunar valves
8. Four chambered heart is found in [NCERT Pg. 282]
   (1) Humans only
   (2) Mammals only
   (3) All vertebrates
   (4) Some reptiles, birds and mammals
9. Purkinje fibres are modified [NCERT Pg. 284]
   (1) Muscle fibres
   (2) Nerve fibres
   (3) Yellow elastic fibres
   (4) White collagen fibres
10. In ECG, P-wave represents [NCERT Pg. 286]
    (1) Depolarisation of ventricles
    (2) Repolarisation of auricles
    (3) Depolarisation of atria
    (4) Excitation of auricles and ventricles
11. Which is **not** related to human heart? [NCERT Pg. 283]
    (1) It has a size of clenched fist
    (2) Mesodermally derived structure
    (3) Protected by double walled pericardium
    (4) Four chambered with right side having thickest wall
12. The opening of the right and left ventricles into the pulmonary artery and the aorta respectively are provided by the [NCERT Pg. 283]
    (1) Mitral valve
    (2) Semilunar valves
    (3) Tricuspid valve
    (4) Bicuspid valve
13. During right ventricular systole, back flow of blood into right atrium is prevented by [NCERT Pg. 285]
    (1) Mitral valve (2) Tricuspid valve
    (3) Bicuspid valve (4) Semilunar valve
14. Number of QRS complexes that occur in the ECG in a given time period determine [NCERT Pg. 286]
    (1) Cardiac output
    (2) Stroke volume
    (3) Heart beat rate
    (4) Strength of heart
15. In which of the following animals, does the heart receive only deoxygenated blood? [NCERT Pg. 282]
    (1) Frog (2) Crocodiles
    (3) Snake (4) Fish
16. In a normal person at rest, each ventricle ejects out [NCERT Pg. 285]
    (1) 1 lt./min (2) 500 ml/min
    (3) 5 lt./min (4) 2 lt./min

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17. Match the following columns and select the **correct** match.

	Column-I		Column-II
(a)	Heart attack	(I)	Heart stops beating
(b)	Cardiac arrest	(II)	Not enough oxygen is reaching heart muscles leading to chest pain
(c)	Heat failure	(III)	Heart is not pumping blood effectively to meet the body's demand
(d)	Angina	(IV)	Heart muscles suddenly damaged by inadequate blood supply

[NCERT Pg. 288]

	(a)	(b)	(c)	(d)
(1)	(IV)	(I)	(II)	(III)
(2)	(IV)	(I)	(III)	(II)
(3)	(I)	(IV)	(III)	(II)
(4)	(I)	(III)	(II)	(IV)

18. Choose the **incorrect** statement [NCERT Pg. 280]

(1) Blood groups are based on presence or absence of natural antigens that can induce immune response

(2) Natural antibodies are proteins produced in response to natural antigens

(3) Anti-A, Anti-B are present in a person having blood group AB

(4) During blood transfusion, blood of donor is carefully matched with blood of recipient

19. Match the column-I and Column-II and select the **correct** option.

	Column-I		Column-II
(a)	Eosinophils	(I)	Transport of gases
(b)	Erythrocytes	(II)	Clotting of blood
(c)	Neutrophils	(III)	Related with allergic reactions
(d)	Platelets	(IV)	Phagocytosis

[NCERT Pg. 279]

	(a)	(b)	(c)	(d)
(1)	(III)	(IV)	(II)	(I)
(2)	(III)	(I)	(IV)	(II)
(3)	(IV)	(I)	(III)	(II)
(4)	(I)	(IV)	(II)	(III)

20. Which contractile layer of the vein is predominantly thinner than the artery in humans? [NCERT Pg. 286]

(1) Tunica intima

(2) Tunica externa

(3) Tunica media

(4) Layer having collagen fibres

Thinking in Context

1. _____ protein of plasma helps in osmotic balance. [NCERT Pg. 279]
2. Plasma without clotting factors is called _____. [NCERT Pg. 279]
3. The most abundant cells among the WBCs are _____. [NCERT Pg. 279]
4. Person with AB blood group can accept blood from person with _____ blood groups. [NCERT Pg. 280]
5. Erythroblastosis foetalis can be avoided by administering _____ to the mother immediately after the _____. [NCERT Pg. 281]
6. _____ ions play a very important role in clotting. [NCERT Pg. 281]
7. Life span of RBCs is _____. [NCERT Pg. 279]
8. Platelets are cell fragments produced by specialized cells in the bone marrow called _____. [NCERT Pg. 280]
9. _____ of the human heart has thickest muscular wall. [NCERT Pg. 283]
10. Lacteals in the intestinal villi majorly absorb _____ from the enterocytes [NCERT Pg. 282]
11. Closure of semilunar valves produce _____ heart sound. [NCERT Pg. 285]

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12. Prominent heart sounds can be heard through instrument named _____. [NCERT Pg. 285]

13. Blood vessels exclusively involved in circulation of blood to and from the cardiac musculature are called _____ [NCERT Pg. 287]

14. Though the heart muscles are auto-excitable, their functions can be moderated by ____ and ____ mechanisms. [NCERT Pg. 287]

15. Pulmonary circulation starts by pumping of deoxygenated blood by _____. [NCERT Pg. 289]

16. Action potential in SAN, increase the flow of blood into the ventricles by about _____%. [NCERT Pg. 284]

17. Return of ventricles from excited to normal state is represented by _____ wave in the ECG. [NCERT Pg. 286]

18. Each time the heart beats, each ventricle pumps out about, 70 ml of blood. This volume is termed as _____. [NCERT Pg. 285]

19. Hypertension is characterized by increase in systolic and diastolic blood pressure beyond ____ and ____ respectively. [NCERT Pg. 287]

20. CAD affect the vessels that supply blood to the ____ muscles. [NCERT Pg. 288]

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Excretory Products and Their Elimination

Chapter 7

1 EXCRETORY WASTE

Metabolism — Excess ingestion

Results in accumulation of

- **Nitrogenous wastes** – NH_3, urea, uric acid
- Other contents – CO_2, H_2O, ions(Na^+, K^+, Cl^-, PO_4^{-3} SO_4^{-2})

Removed ↓

Partially/Completely

2 NITROGENOUS WASTES

- Nature of nitrogenous waste formed and their excretion vary among animals depending on the **habitat/availability of water**.

Major nitrogenous waste	Nature & Examples	Toxicity and water required	Typical
Ammonia	**Ammonotelic** • Aquatic insects • Many bony fishes • Aquatic amphibians	Maximum	• Diffusion through gills surface or body surface as ammoium ions
Urea	**Ureotelic** • Marine fishes • Many terrestrial amphibians • Mammals	Lesser	• **Kidneys** filter urea from blood
Uric acid	**Uricotelic** • Land snails • Insects • Reptiles • Birds	Least	• Pellet/Paste

- Ammonia converts into urea in liver.
- Elimination of urea, uric acid is meant for conservation of water *i.e.*, a type of **terrestrial adaptation**.
- Kidneys do not play a significant role in removal of ammonia.
- Some amount of urea may be retained in the kidney matrix of some animals to maintain desired osmolarity.

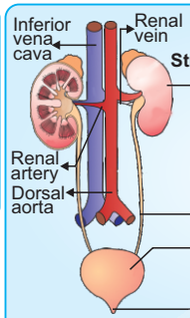
3 EXCRETORY STRUCTURES

- Most invertebrates – Simple tubular forms
- Vertebrates – Complex tubular organs called kidneys

Structures	Examples
Protonephridia / flame cells	Platyhelminthes (*Planaria*)
Nephridia	Rotifers, Some annelids, Cephalochordates (*Amphioxus*)
Malpighian tubules	Annelids (Earthworms), Insects (Cockroaches)
Antennal/ Green glands	Crustaceans (Prawn)

- **Protonephridia** are primarily concerned with **osmoregulation**
- **Function of excretory structures :**
  - Eliminate nitrogenous wastes
  - Maintain ionic and acid-base balance of body fluids, *i.e.*, osmoregulation

4 HUMAN EXCRETORY SYSTEM



Structures Involved

- **Kidney**
  - 1 pair, bean shaped, reddish brown
  - Length 10-12 cm, Width 5-7 cm, Thickness 2-3 cm
  - Weight 120-170 g
  - Between T_{12} - L_3 vertebra, close to dorsal inner wall of abdominal cavity
- **Ureter**
  - 1 pair
- **Urinary bladder**
  - Have stretch receptors
  - Store urine till voluntary signals from CNS carries out its release
- **Urethra**
  - Guarded by sphincters
  - Meant for release of urine

MICTURITION :

- Process of release of urine
- Mechanism - **Micturition reflex**

Urinary bladder (Store urine) → Activates → Stretch receptors → signals → CNS (voluntary signals) → Send motor messages → Urinary bladder
- Smooth muscles contract
- Urethral sphincters relax

→ Release → Urine

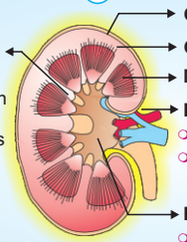
Types of Nephron

Parameters	Cortical	Juxtamedullary
Number	More	Less
Loop of Henle	Too short	Very long
Extension into medulla	Very little	Deep
Vasa recta	Absent / reduced	Present

- **Juxtaglomerular apparatus (JGA)** : Sensitive region formed by cellular modifications in **distal convoluted tubule** and **afferent arteriole** at the location of their **contact**.
- Nephrons are dipped in interstitial fluid having specific osmolarity – Cortex - 300 mOsm / L – Medulla - upto 1200 mOsm/L (Gradient)

5 KIDNEY

Columns of Bertini /Renal columns
- Part of cortex which extents between medullary pyramids



- **Capsule**-outer tough covering
- **Cortex** (Outer) — Zones
- **Medulla** (Inner) — Zones
- **Hilum**
  - Notch towards concave surface
  - Ureter, blood vessels and nerves enter
- **Renal pelvis**
  - Funnel shaped space with projections called calyces

Fig. : Section of kidney

Medullary pyramids are conical masses that project into calyces.

6 NEPHRON

- **Functional unit of kidney**
- Nearly **1 million/kidney**
- Each nephron has two parts - (i) Glomerulus (ii) Renal tubule

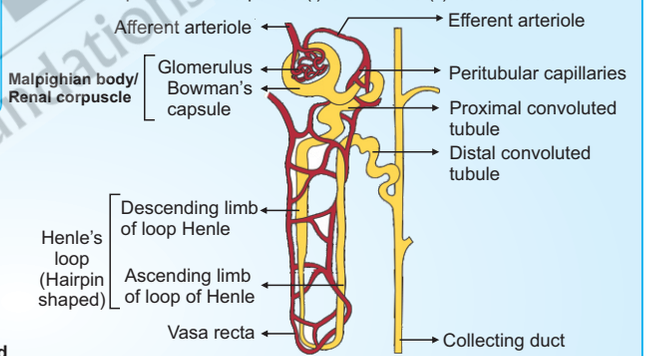


Fig. : Nephron

- **Glomerulus** is a tuft of capillaries formed by **afferent arteriole** - a fine branch of renal artery
- **Malpighian corpuscle, PCT, DCT - Located in cortex**
- Loop of Henle - Dips into medulla
- Many DCTs open into straight tube called **collecting duct**, many of which converge into renal pelvis through medullary pyramids in the calyces
- **Efferent arteriole** emerging from glomerulus forms **peritubular capillaries** around renal tubule
- **Vasa recta :**
  - Branch of peritubular capillaries
  - Parallel to loop of Henle
  - 'U' shaped

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7 URINE FORMATION

Main Processes

1. **Glomerular filtration** — 180 L filtrate /day
2. **Tubular reabsorption** — Nearly **99%** of filtrate get **reabsorbed** by renal tubules
   - By
     - **Active process** — Glucose, Na^+ amino acid
     - **Passive process** — Nitrogenous wastes, H_2O,
3. **Tubular secretion**
   - H^+, K^+ and ammonia secreted into filtrate
   - Maintains ionic and acid base balance

Non-selective process

Glomerular Filtration/Ultra filtration

~ 1/5 of cardiac output or 1100-1200 ml blood/min is filtered by kidneys

Renal Artery → Arterioles → (i) Endothelium of glomerular blood vessels → (ii) Basement membrane → (iii) Epithelium of Bowman's capsule → Glomerular filtrate (Plasma except proteins)

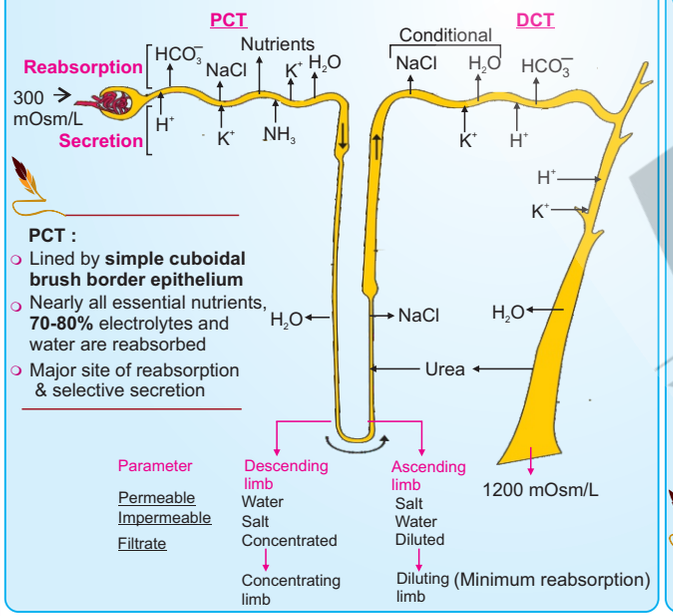
Filtration membrane

Bowman's capsule have **podocytes** arranged in intricate manner so as to leave some spaces called slit **pores / filtration slits**

- Filtration is due to pressure in the glomerular capillaries.
- **Glomerular filtration rate (GFR) = Filtration/min**
  125 ml / min
- Kidney has an ability to regulate GFR.

Urine
1-1.5 L/day

FUNCTIONS OF THE TUBULES

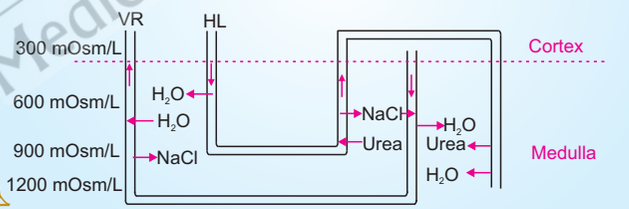


PCT :

- Lined by **simple cuboidal brush border epithelium**
- Nearly all essential nutrients, **70-80%** electrolytes and water are reabsorbed
- Major site of reabsorption & selective secretion

8 COUNTER CURRENT MECHANISM TO CONCENTRATE FILTRATE

- Flow of filtrate in different limbs of following structures are in opposite direction (**Counter current**) :
  - Loop of Henle (HL) • Vasa recta (VR) • HL and VR
- Proximity of HL and VR and counter current in them increase osmolarity towards inner medullary interstitium (300 mOsm/L in cortex to 1200 mOsm/L)
- **Interstitium gradient is caused by NaCl and urea.**
- **NaCl** transported by ascending limb of HL exchanged with descending limb of vasa recta and is returned to medullary interstitium by ascending limb of VR.
- **Urea** which enters in thin part of ascending limb of HL is transported back to interstitium by collecting tubule.
- This mechanism maintain **interstitial concentration gradient** that helps in easy passage of water from collecting tubule thereby concentrating filtrate (urine).



- **HL primarily** helps to **maintain osmolarity gradient** in kidney interstitium.
- Mammals have ability to produce concentrated urine.

9 REGULATION OF KIDNEY FUNCTION / GLOMERULAR FILTRATION RATE

Hypothalamus

Low blood volume/ Body fluid volume/ Ionic concentration → Activate → **Osmoreceptors** of hypothalamus to release ADH/Vasopressin from neurohypophysis → Work

- Constrict blood vessels
- Increase reabsorption of water from DCT (Prevent diuresis)

→ Result

- Blood volume increases
- Blood pressure increases
- GFR increases

Increase in blood volume → Switch off → Osmoreceptors → Suppress → ADH/Vasopressin

JGA

Low GFR/ Glomerular blood flow/ Glomerular blood pressure → Activate → JG cells to release **renin**

Angiotensinogen → Angiotensin I → **Angiotensin II** → Work

- Constrict blood vessel
- Activate adrenal cortex to release aldosterone, that causes reabsorption of Na^+ and water

→ Result

- Blood pressure increase
- GFR increase

(**Renin-Angiotensin** mechanism)

Heart

Increase blood flow to atria of heart → Release of ANF (Atrial natriuretic factor) → Work → Vasodilation → Result

- Blood pressure decrease
- GFR decrease

ANF mechanism acts as a check on Renin-Angiotensin mechanism

10 CHARACTERISTICS AND COMPOSITION OF URINE

- **Colour** - Light yellow
- **pH** = 6
- **Odour** - Characteristic
- Human kidneys can produce urine nearly **4 times** concentrated than initial filtrate.
- **Urea** - 25-30 gm/day
- Various conditions can affect characteristics of urine.

Abnormal constituents of urine	Condition	Indicate
Glucose	Glucosuria	Diabetes mellitus
Ketone bodies	Ketonuria	Diabetes mellitus

Analysis of urine helps in clinical diagnosis of many metabolic disorders as well as malfunctioning of the kidneys.

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11 DISORDERS OF EXCRETORY SYSTEM

Disorders	Symptoms or Treatment
Renal calculi	Stone or insoluble mass of crystalised salts (e.g. oxalates)
Glomerulonephritis	Inflammation of glomeruli of kidney
Renal/kidney failure	Malfunctioning of kidneys leads to accumulation of **urea in blood (Uremia)**, highly harmful, may lead to kidney failure.

Treatment

(i) Haemodialysis : Process to remove urea from blood

Method is a boon for thousands of uremic patients all over the world.

Blood drained from artery → Mix with **Heparin (Anticoagulant)** → Pumped through **Dialysing unit**

Artificial kidney: Porous cellophane tubes surrounded by dialysing fluid

Filtration based on concentration gradient: Nitrogenous wastes freely move out

Clear blood → Mix with Anti coagulant → Pumped back to body through Vein

Composition of dialysing fluid is same as plasma except the nitrogenous wastes

(ii) Kidney transplantation

Ultimate method in correction of **acute renal failure**

- Functional kidney is taken from donor
- To minimize rejection, **close relatives** are **preferred** as donor
- Modern clinical problems have increased success rate of such complicated techniques

12 ROLE OF OTHER ORGANS IN EXCRETION

Accessory structure	Remove	Basic work
Lungs	CO_2, water	❍ Remove large amount of CO_2 approximately **200 mL/min** ❍ Remove significant quantity of water
Liver (Largest gland)	Bilirubin, vitamins biliverdin, drugs cholesterol, degraded steroid hormones	❍ Most of these substances pass out alongwith digestive wastes
Skin ❍ Sweat glands	Sweat contains ❍ NaCl ❍ Urea ❍ Lactic acid	❍ Primary function of sweat is to facilitate **cooling effect** on body surface
❍ Sebaceous glands	Sebum contains ❍ Sterols ❍ Hydrocarbons ❍ Waxes	❍ Sebum provides a protective oily covering for the skin
Salivary glands		❍ Small amount of nitrogenous wastes are eliminated through saliva

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Sharpen Your Understanding

1. Dialysing fluid have the same composition as that of [NCERT Pg. 298]
   (1) Plasma – Nitrogenous wastes
   (2) Serum – Urea
   (3) Lymph – Proteins
   (4) Plasma + Electrolytes + Heparin

2. Sweat produced by sweat glands contain all **except** [NCERT Pg. 298]
   (1) NaCl (2) Urea
   (3) Uric acid (4) Lactic acid

3. Which of the given regulatory mechanisms can be observed once there is increase in volume of body fluid? [NCERT Pg. 297]
   a. Osmoreceptors on hypothalamus switch off
   b. Vasopressin from neurohypophysis is released
   c. Aldosterone causes reabsorption of Na^+ and water
   d. Constriction of blood vessels occur
   (1) a, c only (2) b, c, d only
   (3) a, d only (4) Only a

4. Selective secretion of K^+ and H^+ ions occur in all the following regions **except** [NCERT Pg. 295]
   (1) PCT (2) DCT
   (3) Collecting duct (4) Henle's loop

5. All the following processes are involved in the urine formation **except** [NCERT Pg. 293]
   (1) Glomerular filtration
   (2) Glomerular secretion
   (3) Tubular reabsorption
   (4) Tubular secretion

6. Which of the following is **not** reabsorbed by the kidney? [NCERT Pg. 295]
   (a) Urea (b) Glucose
   (c) Potassium (d) Amino acids
   (e) Creatinine
   Choose the **correct** option.
   (1) (c), (e) (2) (a), (c)
   (3) (b), (d) (4) (e) only

7. Glomerular filtration rate (GFR) is [NCERT Pg. 294]
   (1) 125 mL/day (2) 180 L/day
   (3) 1.25 mL/day (4) 1.8 L/day

8. Which of the given option is **correct** about juxtamedullary nephron? [NCERT Pg. 293]
   (1) They lack vasa recta
   (2) Their loop of Henle runs deep into the medulla
   (3) Their glomerulus is in the outer medulla
   (4) Their peritubular capillaries join to form calyces

NCERT Based MCQs

9. Which of the following is **not** an accessory excretory organ? [NCERT Pg. 298]
   (1) Liver (2) Skin
   (3) Kidneys (4) Lungs

10. Which of the following is released in response to an increase in blood volume and pressure? [NCERT Pg. 297]
    (1) Renin (2) Angiotensin II
    (3) Aldosterone (4) ANF

11. Under which of the following conditions, there will be the presence of abnormally high ketone bodies in urine? [NCERT Pg. 298]
    (a) Fasting for a day
    (b) Diabetes insipidus
    (c) Diabetes mellitus
    (d) Starvation
    (1) (a), (c) (2) (c), (d)
    (3) (b), (c) (4) (a), (b)

12. Counter current mechanism include [NCERT Pg. 296]
    (a) Henle's loop (b) Vasa recta
    (c) PCT (d) DCT
    (1) (b), (c), (d)
    (2) (a), (b), (c)
    (3) (a), (b)
    (4) (b), (c)

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13. Which of the following function is **not** concerned with kidney? [NCERT Pg. 294]
(1) Acid-base balance
(2) Maintenance of blood pressure
(3) Detoxification of body fluids
(4) Excretion of nitrogenous wastes

14. How many of the following organisms in a box are uricotelic? [NCERT Pg. 290]

Land snail, Bony fishes, Reptiles, Amphibians

(1) One (2) Two
(3) Three (4) Four

15. Osmolarity of interstitial fluid is equivalent to that of blood plasma at [NCERT Pg. 296]
(1) Interstitial fluid in cortex
(2) Base of loop of Henle
(3) Inner medullary interstitium
(4) Median medullary interstitium

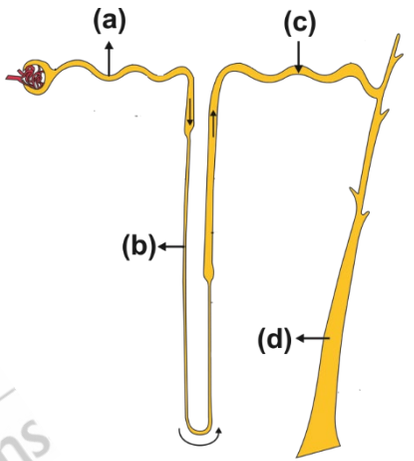
16. Podocytes are associated with the wall of [NCERT Pg. 293]
(1) Glomerular capillaries
(2) Proximal convoluted tubule
(3) Bowman's capsule
(4) Distal convoluted tubule

17. Choose the **correct** sequence on the basis of their decreasing toxicity.[NCERT Pg. 290]
(1) Uric acid – Urea – Ammonia
(2) Ammonia – Uric acid – Urea
(3) Uric acid – Ammonia – Urea
(4) Ammonia – Urea – Uric acid

18. Haemodialysis is most commonly used for [NCERT Pg. 298]
(1) Renal calculi
(2) Uremia
(3) Oedema
(4) Glycosuria

19. During urine formation, which process is non-selective? [NCERT Pg. 299]
(1) Tubular reabsorption
(2) Tubular secretion
(3) Glomerulus filtration
(4) Ultrafiltration and tubular secretion

20. Choose the **correct** option corresponding to labels a, b, c and d in the given diagram. [NCERT Pg. 295]



	(a)	(b)	(c)	(d)
(1)	H_2O	H_2O	HCO_3^-	Uric acid
(2)	HCO_3^-	H_2O	K^+	Urea
(3)	NH_3	NaCl	H_2O	Urea
(4)	K^+	NaCl	H_2O	H^+

Thinking in Context

1. _____ is the excretory structure in Platyhelminthes. [NCERT Pg. 291]
2. Average length and width of kidney in humans is a_____ and _____ respectively. [NCERT Pg. 291]
3. Primary function of sweat is to facilitate _____ [NCERT Pg. 298]
4. _____ hormone facilitate reabsorption of water from the DCT and prevent diuresis. [NCERT Pg. 297]
5. _____ does not constitute a part of single uriniferous tubule. [NCERT Pg. 293]
6. Urinary bladder opens out through _____. [NCERT Pg. 291]

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7. Part of nephron which shows minimum reabsorption of contents is _____. [NCERT Pg. 294]
8. Concentration gradient in the medullary interstitium is mainly caused by _____ and _____. [NCERT Pg. 296]
9. Glomerulus and its surrounding Bowman's capsule together form a specialized structure called _____. [NCERT Pg. 292]
10. In a normal healthy adult, on an average _____ of urea is excreted out per day. [NCERT Pg. 298]
11. The greatest fraction of water is reabsorbed in _____. [NCERT Pg. 294]
12. Expulsion of urine from urinary bladder is _____. [NCERT Pg. 297]
13. _____ act as semipermeable membrane during haemodialysis. [NCERT Pg. 298]
14. In micturition, urethral sphincters are _____. [NCERT Pg. 298]
15. Henle's loop primarily helps to maintain osmotic gradient ranges between _____ to _____ within the kidney interstitium. [NCERT Pg. 300]
16. Process of separation of metabolic wastes from blood through artificial means is known as _____. [NCERT Pg. 298]
17. Fine capillary network emerging from efferent arteriole is called _____. [NCERT Pg. 293]
18. Increase in blood volume and blood pressure stimulate specific cells of cardiac atria to secrete _____ to cause vasodilation. [NCERT Pg. 297]
19. Urine is _____ times more concentrated than blood plasma. [NCERT Pg. 297]
20. Juxtaglomerular cells produce _____ enzyme in response to fall in glomerular filtration rate. [NCERT Pg. 297]

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Locomotion and Movement

Chapter 8

1 MOVEMENT AND LOCOMOTION

- **Movement** • Significant feature of living beings
- **Locomotion** • **Voluntary** movements resulting in change in place/location.
- Locomotion is performed by organisms for variable reasons, *e.g.,*
  - Their habitats
  - Demand of situation like search of food, mate, breeding ground, escape from enemies/predators

2 TYPES OF MOVEMENT / LOCOMOTION

Type	Structure	Examples and functions
Amoeboid	Pseudopodia involve microfilaments and streaming of protoplasm	Leucocytes, macrophages, *Amoeba*
Ciliary	Cilia	Removing dust particles from trachea Passage of ova through female reproductive tract
Flagellar	Flagella	Maintenance of water current in canal system of sponges Locomotion in *Euglena* Swimming of spermatozoa
Muscular	Muscles	Movement of limbs, jaws, tongue Running, walking, climbing, flying

- **All locomotions are movements but all movements are not locomotion.**
- In ***Paramoecium*** - Cilia helps in movement of food through cytopharynx and in locomotion as well.
- In ***Hydra*** - Tentacles are used for capturing of prey & also for locomotion.
- **Locomotion** requires a perfect coordinated activity of **muscular, skeletal** and **neural** systems.

3 MUSCLES

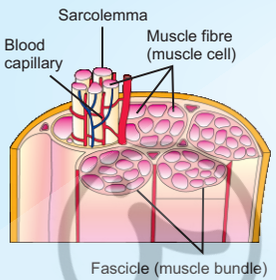
- **Muscle tissue:** Mesodermal in origin
- **40-50%** of body weight of a human adult is contributed by muscles.
- **Properties** • Excitability • Contractility • Extensibility • Elasticity
- Many cardiac muscle cells assemble in **branching** pattern to form a cardiac muscle

Classification of muscles

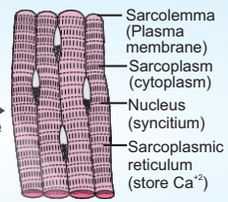
Basis	Location	Appearance	Regulation	Example
1.	Skeletal	Striated	Voluntary	Muscles of limbs
2.	Visceral	Non-striated/smooth	Involuntary	Inner walls of visceral organs
3.	Cardiac	Striated	Involuntary	Muscles of heart

4 SKELETAL MUSCLE FIBRES & ITS TYPES

- Skeletal muscles are closely associated with the skeletal components of the body.



Skeletal muscle
↓ Many
Muscle fibre bundles/ Fascicles
↓ Held by
Fascia (collagenous connective tissue)
→ Many muscle fibres



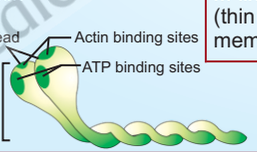
	Types	
	Red	**White**
Myoglobin	↑	↓
Mitochondria	↑	↓
SR	↓	↑
Respiration	Mainly aerobic	Mainly anaerobic

- Each muscle fibre have many parallelly arranged myofibrils / myofilaments.
- **Muscle fibre: Anatomical unit of muscle.**
- Skeletal muscles are primarily involved in locomotion and change in body posture.

5 MYOFILAMENTS AND STRUCTURE OF CONTRACTILE PROTEINS

Each myofibril has dark and light bands due to actin and myosin distribution that establish striated appearance.

	Filament	Held by	Protein	Monomer	Polymer	Typical
Light/I-band	Thin/actin	Z-line (bisect I-band)	Actin (contractile)	Globular 'G' - actin	Filamentous 'F'-actin	F-actin helically arranged
			Tropomyosin	—	—	Tropomyosin run close to F-actin throughout its length
			Troponin	3		Troponin distributed at regular intervals on tropomyosin Mask active binding sites for myosin on actin filaments
Dark/A-band	Thick	M-line (thin fibrous membrane)	Myosin (contractile)	Meromyosin (MM)	HMM (Heavy) - Head - **Short arm** LMM (Light) - Tail	Project outward at regular distance and angle from each other from the surface of polymerised myosin filament and is known as **cross arm**.



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6 MECHANISM OF MUSCLE CONTRACTION/ SLIDING FILAMENT THEORY

- Contraction of muscle fibre takes place by the sliding of the **thin filaments over the thick filaments**.
  A motor neuron alongwith the muscle fibres connected to it constitute a **motor unit**.

CNS → *via* Motor neuron → Release → Neurotransmitter Acetylcholine

↓

At **Neuromuscular Junction** / **Motor end plate**, action potential is generated in sarcolemma that causes release of Ca^{+2} in sarcoplasm from SR leading to **Ca^{+2} increase** in sarcoplasm

↓

Ca^{+2} binds to troponin subunit, change in its confirmation, unmask active site for myosin binding on actin filament

↓

Energised myosin (Myosin – ADP + Pi) binds to actin

↓

Cross bridge = Actin-myosin-ADP + Pi

↓

Result (Shortening/ contraction of sarcomere)
- Pull thin filaments toward centre
- Pull Z-line
- Length of I-band reduced
- Length of A-band retained

↓

ADP+Pi released from myosin head

↓

New ATP binds to myosin head

↓

Cross bridge broken

↓

ATP hydrolysis on myosin head

↓

Cycle repeats

↓

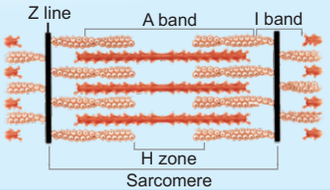
Process will continue till Ca^{2+} pumped back to sarcoplasmic cisternae

↓

Z-line return to original position

- **Reaction time** of fibres vary in different muscles.
- Repeated activity of muscle leads to accumulation of **lactic acid** due to **anaerobic** breakdown of **glycogen** in them, causing **fatigue**.

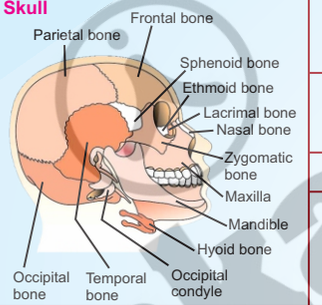
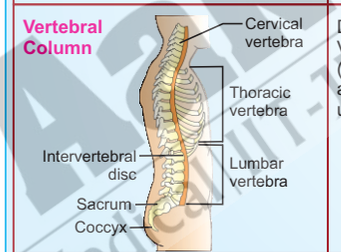
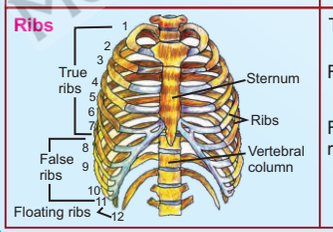
- **Globular head** is active **ATPase enzyme** and has binding sites for ATP and active sites for actin.
- Thin filaments make I/Isotropic band – actin
  Thick filaments make A/Anisotropic band – actin + myosin
  } Arranged alternately throughout the length of myofibrils parallel to each other and to longitudinal axis of myofibrils
- **Sarcomere: Functional unit** of contraction between 2 'Z' lines (elastic fibres) = **1 A-band + 2 half I-band**
- H-zone is non overlapped part of thick filament by thin filaments.



7 SKELETAL SYSTEM

- This system has significant role in movement shown by the body.
- **Framework of 206 bones & few cartilages**
- **Principle division** • Appendicular skeleton • Axial skeleton

Axial skeleton (Bones-80)
Bones distributed along main axis

Structure	Bones included	No.	Name of bones	Typical feature or basic function
Skull 	Cranium	8	1- Frontal 1- Occipital 2- Parietal 1- Ethmoid 2- Temporal 1- Sphenoid	- Protect brain - Articulates with superior region of vertebral column by 2 occipital condyles **(Dicondylic skull)**
	Facial	14	2- Nasal 1- Mandible 2- Lacrimal 2- Maxilla 2- Zygomatic 5- others	- Form front part of skull
	Hyoid	1	1- U-shaped	- Present at the base of buccal cavity
	Ear ossicles	6	2-Malleus 2-Incus 2-Stapes	- Present in the middle ear
Vertebral Column 	Dorsal Vertebrae (serially arranged units)	26	7- Cervical 12- Thoracic 5- Lumbar 1- Sacral-Fused 1- Coccygeal-Fused	- Main framework of trunk - Protects spinal cord - Supports head - Point of attachment of ribs and muscles of back ○ 1st vertebra is **atlas** that articulates with **occipital condyles**. ○ **Seven cervical vertebrae** exist in almost all mammals. ○ **Neural canal** of vertebrae - site from where spinal cord passes
Sternum	Chest bone	1	1-Flat bone	- On ventral, midline of thorax
Ribs 	True ribs	24	14-Vertebrosternal	- Attach dorsally to vertebrae and ventrally to sternum with **hyaline cartilage**
	False ribs		6- Vertebrochondral	- Not directly attached to sternum but to 7th rib with **hyaline cartilage** (8th to 10th pair)
	Floating ribs		4- Vertebral	- Not connected ventrally (11th and 12th pair) ○ All ribs are **bicephalic thin flat bones** *i.e.,* they have 2 articulating ends on dorsal side ○ Vertebral column + Sternum + Ribs = **Rib Cage**

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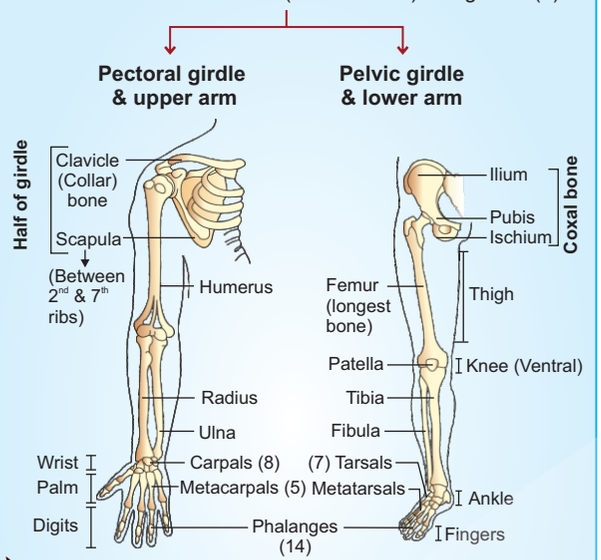
8 APPENDICULAR SKELETON (BONES - 126)

- Consists of bones of limbs (30 × 4 = 120) and girdles (6)



- Girdles helps in the articulation of limbs with axial skeleton
- Scapula, a dorsal triangular flat bone, have elevated ridge/spine, expanded to form **acromion process** that articulates with clavicle
- **Glenoid cavity** in scapula articulates with humerus head to form shoulder joint
- **Acetabulum**, formed by fusion of ilium, ischium and pubis, articulates with femur to form hip joint
- 2 halves of pelvic girdle meet ventrally to form **pubic symphysis** containing **fibrous cartilage**

9 JOINTS

- They are essential for all types of movements involving bony parts of the body.
- Point of contact between bones or bones and cartilages.
- Force generated by muscle is used to carry out movement through joint, where joint acts as **fulcrum**.
- **Types of joints** (Basis – Major structural forms)

Types	Bones joined by	Movement	Examples
Fibrous	Dense fibrous connective tissue	Do not allow any movement	Flat skull bones fused end to end *via* **sutures** to form **cranium**
Cartilaginous	Fibrous cartilage	Limited movement	Adjacent vertebrae
Synovial	Fluid filled synovial cavity between 2 bones	Considerable movement, helps in locomotion and many other movements	Humerus & pectoral girdle (**Ball and socket joint**) Knee joint (**Hinge joint**) Atlas & axis (**Pivot joint**) Between carpals (**Gliding joint**) Carpal & metacarpal of thumb (**Saddle joint**)

10 DISORDERS

Disease	Causes	Impact
Myasthenia gravis	Autoimmunity	Affect neuromuscular junction Fatigue, weakening and paralysis of skeletal muscles
Muscular dystrophy	Genetic	Progressive degeneration of skeletal muscles
Tetany	Low Ca^{+2} in body fluid	Rapid spasms in muscle (wild contractions)
Arthritis		Inflammation of joints
Gout	Accumulation of uric acid crystals	Inflammation of joints
Osteoporosis	Age related Decreased levels of estrogen	Decreased bone mass, increased chances of fracture

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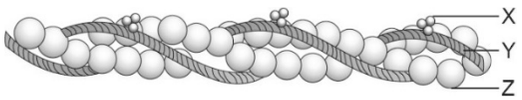
Sharpen Your Understanding

1. Identify the structures labelled as X, Y and Z in the given figure [NCERT Pg. 306]



Which of the above structure(s) masks the myosin binding site on actin filament during resting state?

(1) X only (2) Y and Z

(3) X and Z (4) Y and Z

2. Which of the following when binds to the myosin head results in its detachment from actin? [NCERT Pg. 307]

(1) Ca^{+2} (2) Mg^{+2}

(3) ATP (4) ADP

3. Choose the **odd** one w.r.t. locomotion [NCERT Pg. 302]

(1) *Hydra* use tentacles for capturing prey

(2) Use of hind limbs for search of food in different fields

(3) Climbing a tree

(4) Flying to escape from predators

4. Pseudopodial movements are characteristic of all **except** [NCERT Pg. 303]

(1) Leucocytes (2) *Amoeba*

(3) Macrophages (4) Ova

5. Which is **not** correct about muscle? [NCERT Pg. 303]

(1) It is mesodermal in origin

(2) 40-50% of body weight is formed by it

(3) They have properties like excitability and contractibility

(4) They are classified on the basis of reception of type of stimulus

6. The red and white muscle fibres can be distinguished from each other on the basis of all **except** [NCERT Pg. 308]

(1) Amount of myoglobin

(2) Dependence on aerobic process of energy

(3) Amount of sarcoplasmic reticulum

(4) Thickness & length of actin & myosin filaments

7. The central part of thick filaments, not overlapped by thin filament at relaxed state of muscle fibre is [NCERT Pg. 305]

(1) H-zone (2) I-band

(3) A-band (4) Sarcomere

8. During the mechanism of muscle contraction, following events occur.

A. Myosin head activated by ATP hydrolysis binds to exposed active sites to form cross bridge.

B. Pulling of actin filaments towards A-band leads to contraction.

C. Acetylcholine is released at neuromuscular junction which generate action potential.

D. Release of Ca^{+2} ions from SR, binds to subunit troponin of actin filaments.

Which of the following sequence of above events is **correct**? [NCERT Pg. 307]

(1) A, B, C, D (2) C, D, B, A

(3) C, D, A, B (4) C, B, D, A

9. In order to initiate muscle contraction, Ca^{+2} ions binds to which of the following muscle protein? [NCERT Pg. 307]

(1) Tropomyosin (2) Actin

(3) Troponin (4) Myosin

10. I-band lacks [NCERT Pg. 306]

(1) Actin (2) Tropomyosin

(3) Myosin (4) Troponin

11. Select the **incorrect** pair. [NCERT Pg. 309, 310]

(1) Axial skeleton – 80 bones

(2) Skull region – 22 + 1 + 6 bones

(3) Vertebrosternal ribs – 2 pairs

(4) Vertebrochondral ribs – 3 pairs

NCERT Based MCQs

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12. Which set of bones are single in human body? [NCERT Pg. 309, 311]
(1) Nasal, coxa
(2) Mandible, hyoid
(3) Temporal, sternum
(4) Frontal, maxilla

13. Match the appropriate number of the bones associated with given structures and choose the **correct** option [NCERT Pg. 310, 311]

a.	Limb bones	(i)	12
b.	Thoracic vertebrae	(ii)	2
c.	Hip girdle	(iii)	30
d.	Lumbar vertebrae	(iv)	5
		(v)	3

(1) a(iii), b(i), c(ii), d(iv)
(2) a(iii), b(i), c(v), d(iv)
(3) a(iv), b(i), c(ii), d(iii)
(4) a(iii), b(ii), c(i), d(iv)

14. Which of the following option include the bones whose number is **not** same in upper and lower limbs? [NCERT Pg. 311]
(1) Humerus and femur
(2) Metacarpals and metatarsals
(3) Radius and tibia
(4) Carpals and tarsals

15. Presence of a coxal bone formed by the fusion of three smaller bones is a feature of [NCERT Pg. 311]
(1) Pectoral girdle (2) Pelvic girdle
(3) Vertebral column (4) Tarsals

16. Acetabulum is bounded by [NCERT Pg. 311]
(1) Ischium and pubis only
(2) Ilium and pubis only
(3) Ilium, ischium and pubis
(4) Pubis only

17. Which pair of ribs do **not** articulate directly with the sternum but attach with hyaline cartilage of other ribs? [NCERT Pg. 310]
(1) 6^{th}, 7^{th}, 8^{th} (2) 8^{th}, 9^{th}, 10^{th}
(3) 7^{th}, 8^{th}, 9^{th} (4) 10^{th}, 11^{th}, 12^{th}

18. Which of the following joints does **not** allow any movement in our body? [NCERT Pg. 312]
(1) Between adjacent vertebrae
(2) Pubic symphysis in pelvic girdle
(3) Between skull and atlas
(4) Suture in skull bones

19. Which of the given disorder is commonly caused by decreased level of estrogen in aged woman? [NCERT Pg. 310]
(1) Arthritis
(2) Osteoporosis
(3) Myasthenia gravis
(4) Gout

20. During contraction and relaxation of skeletal muscle, size of which band remains unchanged? [NCERT Pg. 308]
(1) I-band
(2) A-band
(3) H-zone
(4) Z-line

Thinking in Context

1. Acromion process is the part of _____ bone. [NCERT Pg. 311]

2. Store house of Ca^{+2} ions in striated muscle fibres is _____. [NCERT Pg. 304]

3. Muscle bundles are held together by a common collagenous connective tissue layer called _____. [NCERT Pg. 304]

4. Spermatozoa show _____ movement. [NCERT Pg. 303]

5. M-line is present in the middle of _____ band. [NCERT Pg. 305]

6. Monomeric unit of thick myosin filament is called _____. [NCERT Pg. 306]

7. Ribs have two articulation surfaces on _____ side so are called _____. [NCERT Pg. 310]

8. _____ is the autoimmune disorder affecting neuromuscular junction. [NCERT Pg. 312]

9. _____ is the fundamental contractile unit of a skeletal myofibril. [NCERT Pg. 308]

10. Patella covers the knee _____. [NCERT Pg. 311]

11. Our palm is formed of _____ bones. [NCERT Pg. 311]

12. Maximum movement is possible at _____ joints. [NCERT Pg. 312]

13. Red colour of red muscle fibres is due to oxygen storing pigment called _____. [NCERT Pg. 308]

14. Pliable nature of cartilage is due to _____. [NCERT Pg. 309]

15. The cross arm of myosin head has two sites to bind with _____ and _____. [NCERT Pg. 306]

16. _____ is the longest bone in our body. [NCERT Pg. 311]

17. Pubic symphysis is a type of _____ joint. [NCERT Pg. 311]

18. In a shoulder joint, head of humerus articulates with _____ cavity. [NCERT Pg. 311]

19. Tetany, a rapid spasm in muscle is due to _____ ions in body fluid. [NCERT Pg. 312]

20. Ventral side of thorax is supported by _____ bone. [NCERT Pg. 310]

❑ ❑ ❑

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Neural Control and Coordination

9A Chapter

1 INTRODUCTION

- Coordination is the process through which two or more organs **interact** and **complement** the functions of one another to **maintain homeostasis** in our body.
- The **neural system** and the **endocrine system** jointly coordinate and integrate all the activities of the organs so that they **function in a synchronised fashion.**

2 SYSTEMS MAINTAINING HOMEOSTASIS

PARAMETERS	NEURAL SYSTEM	ENDOCRINE SYSTEM
Integration	Through neurotransmitters	Through hormones
Coordination	Quicker	Slower

- **Neural system** provides an organised network of **point to point connections** with target cells.

3 NEURON

- Neuron is the structural and functional unit of the neural system
- **Composed** of a cell body, dendrites and axon

Types	No. of Dendrites	Location
Multipolar	2 or more	Cerebral cortex
Bipolar	1	Retina of eye
Unipolar	0	Embryonic stage

- Above given neurons have only one axon.
- Cell body contains cell organelles.
- Impulse from dendrite moves towards cell body and in axon away from cell body.

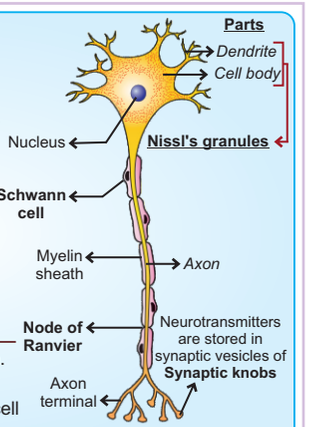


Fig.: Structure of a neuron

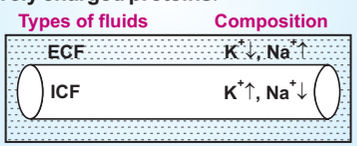
4 TYPES OF AXONS/NERVE FIBRES

Parameters	Myelinated	Non-myelinated
Myelin sheath	+	–
Node of Ranvier	+	–
Location	Cranial & spinal nerves	Autonomic and somatic neural system

- **Schwann cells surround both myelinated and non-myelinated nerve** fibres but they form myelin sheath only in myelinated fibres.

5 CONCENTRATION GRADIENT ACROSS AXONAL MEMBRANE

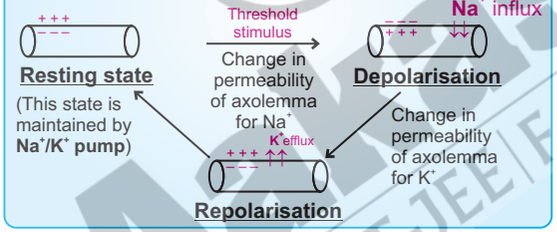
- **Excitability of neurons is attributed** to polarised state of neural membranes.
- It has **selectively permeable ionic channels** responsible for differential concentration gradient across the axonal membrane
- **Axonal membranes** are **more permeable for K^+, nearly impermeable to Na^+** and **impermeable** to **negatively charged proteins**.



- **Ionic gradients** across resting membrane are maintained by the active transport of ions by the **sodium-potassium pump** which pumps $3Na^+$ outwards and $2K^+$ into the cell

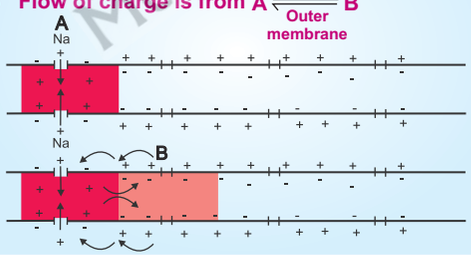
6 GENERATION OF IMPULSE

- The electrical potential difference across the resting plasma membrane is called the **resting potential**
- The electrical potential difference across the axonal membrane after receiving **threshold stimulus** is called **action potential/nerve impulse.**
- **Cycle of events:**



7 CONDUCTION OF IMPULSE

- Impulse generated at a site arrives at another site and same sequence is repeated along the length of axon.
- **Current flows in a circuit when it moves from A to B site.**
- **Flow of charge is from A** Inner ⇌ Outer membrane **B**

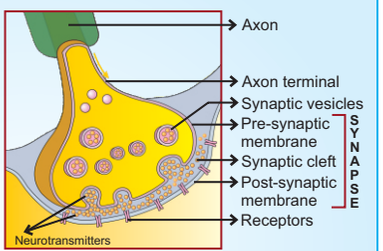


8 TRANSMISSION OF IMPULSE

- Nerve impulse is transmitted from one neuron to another across a **synapse**.

Events observed:

- Neurotransmitters released in synaptic cleft
- Bind to receptors on post synaptic neuronal (PSN) membrane
- Opening of ion channels in PSN
- Generates a new potential in PSN



Types of Synapse		
Features	**Electrical synapse**	**Chemical synapse**
Pre & post neuron	Close proximity through gap junctions	Separated by fluid-filled synaptic cleft
Flow of impulse	Direct	Through neurotransmitters
Transmission	Faster	Slower
Nature	–	Excitatory or inhibitory
Existence	Rare	Common

- Transmission of impulse across electrical synapse is very similar to impulse conduction along a single axon.

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9 NEURAL SYSTEM

- **Neurons can detect, receive & transmit stimulus**
  - *Hydra* – Network of neurons
  - Insects – Organised neural system with brain and ganglia
  - Vertebrates – Well developed neural system

10 HUMAN NEURAL SYSTEM

CNS
- Brain & spinal cord

PNS
- All **nerves** of body from brain and spinal cord
- **Nerve fibres of PNS**

Afferent
Send impulses from tissues/organs to CNS

Efferent
Transmit impulses from CNS to peripheral tissues/organs

Somatic neural system
Transmit impulses from CNS to skeletal muscles

Autonomic nervous system
Relays impulses from CNS to involuntary organs and smooth muscles

Visceral nervous system (VNS)
- Part of PNS
- Complex of nerves, fibres, ganglia and plexuses
- CNS $\underset{\text{VNS}}{\rightleftharpoons}$ viscera

11 CENTRAL NERVOUS SYSTEM

- **Acts as command & control system of the body**
- **Protective coverings**
  - Skull
  - Meninges

	Outer	Middle	Inner
Name of meninx	Duramater	Arachnoid	Piamater
In contact with	Skull		Brain

Major Divisions of Brain:

Divisions	Major parts
Forebrain	Cerebrum, thalamus, hypothalamus
Midbrain	Corpora quadrigemina
Hindbrain	Pons, medulla, cerebellum

13 REFLEX ACTION AND REFLEX ARC

- Its a response to peripheral nervous stimulation
- **Involuntary *i.e.*, without conscious effort**
- Involves part of CNS.

Reflex pathway

Receptor $\xrightarrow{\text{Afferent neuron}}$ CNS $\xrightarrow{\text{Efferent neuron}}$ Effector/Excitor

- Neurons are **arranged in series** in a reflex pathway.
- **Afferent neurons** transmit impulse via **dorsal nerve root**.
- **Inter neuron is not a part of this stretch reflex**

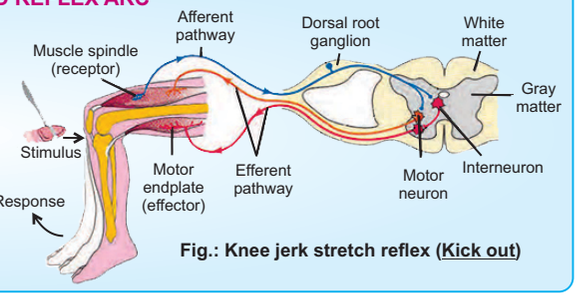

Fig.: Knee jerk stretch reflex (Kick out)

12 BRAIN

- **Brain** is central information processing organ of the body

Forebrain

- **Cerebrum**
  - Major part of brain
  - Cleft divides it longitudinally into right & left **cerebral hemispheres**, connected by **corpus callosum**
- **Thalamus**
  - Major coordinating centre for sensory & motor signaling
- **Hypothalamus**
  - Lies at base of thalamus
  - Has various centres for controlling body temperature, urge for eating and drinking
  - Secretes hormones

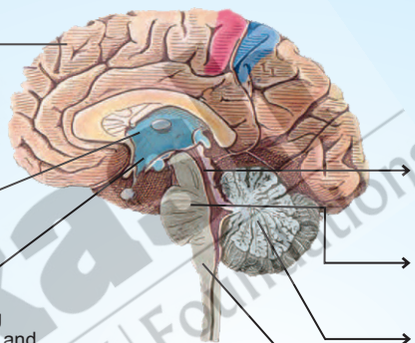

Fig.: Sagittal section of human brain

Regions in cerebral hemisphere	Appearance	Composition
Outer/cortex	Grey	Concentrated cell bodies
Inner	White	Myelinated nerve fibres

- The **cerebral cortex** includes

Sensory areas | **Motor areas** | **Association areas** (Neither sensory nor motor)

Functions

Inter sensory associations | Memory | Communication

- **Limbic system/Limbic lobe**
  - **Parts included:** Inner part of cerebral hemisphere, hippocampus, amygdala and hypothalamus
  - **Functions:** Involved in expression of emotional reactions (e.g., excitement , pleasure, rage, fear), Motivation, Regulation of sexual behaviour, Autonomic responses, Olfaction

Midbrain

- **Corpora Quadrigemina**
  - located between thalamus/hypothalamus and pons
  - 4 lobes on dorsal side between forebrain and pons.
  - Integrates visual, tactile and auditory inputs.
- **Cerebral Aqueduct**
  - Canal passes through midbrain

Hindbrain

- **Pons**
  - Fibrous tract that connects different regions of the brain
- **Cerebellum**
  - Convoluted surface to accommodate more neurons
  - Integrates information received from semicircular canal and auditory system
- **Medulla oblongata**
  - Connects brain to spinal cord
  - Has centres for controlling respiration, cardiovascular reflexes and gastric secretions

- **Brain Stem is composed of Midbrain, Pons and Medulla oblongata**

Basic Functions of Brain

- Controls the voluntary movements
- Balance of body
- Functioning of vital organs (kidneys, lungs, heart)
- Thermoregulation
- Controls hunger, thirst
- Circadian rhythms
- Human behaviour
- Activities of endocrine glands

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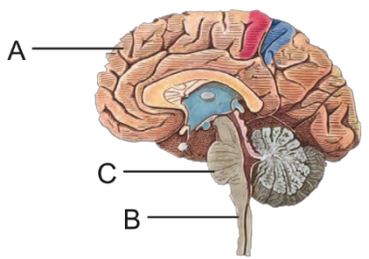
Sharpen Your Understanding

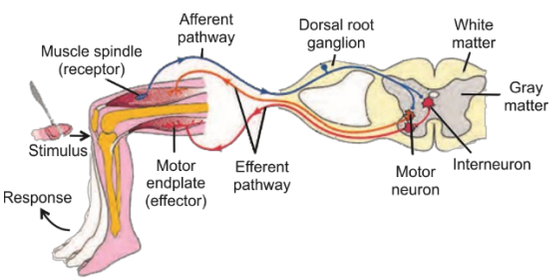
1. Which neural system relays impulses from CNS to the skeletal system? [NCERT Pg. 316]
   (1) Sympathetic neural system
   (2) Parasympathetic neural system
   (3) Somatic neural system
   (4) Autonomic neural system
2. Which is the major coordinating centre for sensory and motor signaling? [NCERT Pg. 321]
   (1) Hypothalamus
   (2) Thalamus
   (3) Cerebrum
   (4) Midbrain
3. In the given diagram, identify A, B and C. [NCERT Pg. 320]



	A	B	C
(1)	Cerebellum	Medulla	Pons
(2)	Cerebrum	Medulla	Pons
(3)	Cerebrum	Pons	Olfactory lobe
(4)	Corpus callosum	Cerebrum	Medulla

NCERT Based MCQs

4. In a resting membrane, K^+ passively moves from [NCERT Pg. 317]
   (1) Axoplasm to ECF by diffusion
   (2) ECF to axoplasm by diffusion
   (3) Axoplasm to ECF by gated channels
   (4) ECF to axoplasm by gated channels
5. Which of the given meninges is in contact with brain tissue? [NCERT Pg. 320]
   (1) Piamater
   (2) Arachnoid
   (3) Dura mater
   (4) Pia-arachnoid
6. Corpus callosum, a tract of nerve fibres connects [NCERT Pg. 321]
   (1) Two cerebellar hemispheres
   (2) Two cerebral hemispheres
   (3) Cerebellar and cerebral hemispheres
   (4) Four lobes of corpora quadrigemina
7. Cardiovascular centre is present in [NCERT Pg. 321]
   (1) Pons
   (2) Cerebellum
   (3) Medulla oblongata
   (4) Cerebrum
8. Which is **not** a part of brain stem? [NCERT Pg. 321]
   (1) Pons
   (2) Cerebellum
   (3) Medulla oblongata
   (4) Midbrain
9. Limbic system includes [NCERT Pg. 321]
   a. Amygdala
   b. Hippocampus
   c. Hypothalamus
   d. Midbrain
   e. Corpora quadrigemina
   (1) a, c, d (2) c, d, e
   (3) a, b, c (4) a, b, c, e
10. Which statement is **not** related to the following diagrammatic presentation? [NCERT Pg. 322]



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(1) It is showing knee jerk reflex

(2) It shows two reflex arcs

(3) Knee jerk arc has only one synapse in CNS

(4) Multisynaptic reflex arc goes to the same muscle to relax it

11. Select the organism having simplest form of neural organization. [NCERT Pg. 316]

(1) *Spongilla*

(2) *Hydra*

(3) *Pheretima*

(4) *Apis*

12. Nissl's granules exist in [NCERT Pg. 317]

(1) Cell body and axon

(2) Axon and synaptic knob

(3) Cell body and dendrites

(4) Axon and dendrites

13. After depolarisation, resting membrane potential is restored within fraction of second due to X and is maintained by Y. [NCERT Pg. 318]

	X	Y
(1)	Efflux of Na^+	Influx of K^+
(2)	Influx of Na^+	Efflux of K^+
(3)	Efflux of K^+	Na^+-K^+ pump
(4)	Influx of K^+	Na^+-K^+ pump

14. Na^+-K^+ pump transports which of the following ions across plasma membrane of neuron? [NCERT Pg. 317]

	Outside	Inside
(1)	3 Na^+	2 K^+
(2)	2 Na^+	3 K^+
(3)	3 K^+	2 Na^+
(4)	2 K^+	3 Na^+

15. Which system provides an organised network of point-to-point connections for a quick coordination? [NCERT Pg. 315]

(1) Neural system

(2) Endocrine system

(3) Feedback system

(4) Neuroendocrine system

16. Cell body with only one axon as a cell process is found in [NCERT Pg. 317]

(1) Retina of eye

(2) Embryonic stage

(3) Dorsal root ganglia of spinal nerve

(4) Cerebral cortex

17. Which area of cerebral cortex is responsible for complex functions like intersensory associations, memory and communications? [NCERT Pg. 321]

(1) Sensory area

(2) Motor area

(3) Association area

(4) Afferent area

18. Which of the following has very convoluted surface in order to provide the additional space for many more neurons? [NCERT Pg. 321]

(1) Pons

(2) Olfactory lobes

(3) Cerebellum

(4) Medulla

19. Voluntary muscular coordination is under the control of [NCERT Pg. 321]

(1) Hypothalamus

(2) Cerebellum

(3) Cerebral hemisphere

(4) Medulla oblongata

20. Which of the given options is **not** absolutely essential for all reflex actions? [NCERT Pg. 322]

(1) Receptor organ

(2) Interneuron

(3) Afferent and efferent neuron

(4) Part of CNS

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Thinking in Context

1. _____ is the process through which two or more organs interact and complement the functions of one another. [NCERT Pg. 315]
2. Impulse transmission is faster in _____ as compared to _____ synapse. [NCERT Pg. 319]
3. Central information processing organ of our body is _____ that acts as the command and control system. [NCERT Pg. 320]
4. The chemical senses of _____ and _____ are functionally similar and interrelated. [NCERT Pg. 323]
5. _____ control our body temperature. [NCERT Pg. 321]
6. Cerebrum is divided into two halves along _____ axis and are connected by the corpus callosum. [NCERT Pg. 327]
7. Cerebral cortex contains motor areas, sensory areas and _____ areas. [NCERT Pg. 321]
8. In vertebrates _____ plays a central role in integrating endocrine and nervous system. [NCERT Pg. 321]
9. Cerebral aqueduct passes through _____ and connect cavities between _____ and _____ brain. [NCERT Pg. 321]
10. _____ part of brain connects brain with the spinal cord. [NCERT Pg. 321]
11. Sympathetic and parasympathetic system are a part of _____ neural system. [NCERT Pg. 316]
12. Cerebral cortex is made up of _____ matter. [NCERT Pg. 321]
13. Amygdala controls _____. [NCERT Pg. 321]
14. Centre for cardiovascular reflexes is present in _____. [NCERT Pg. 321]
15. Myelin sheath in peripheral nervous system is formed by _____ cells. [NCERT Pg. 317]
16. Visceral nervous system is the part of _____. [NCERT Pg. 321]
17. _____ part of human neural system is a site of processing of vision, hearing and thoughts. [NCERT Pg. 320]
18. Corpora quadrigemina are present on _____ side of midbrain. [NCERT Pg. 321]
19. Withdrawal of leg when touched with hot thing is a type of _____. [NCERT Pg. 322]
20. _____ part of brain is responsible for co-ordination between different muscular activities. [NCERT Pg. 321]

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Neural Control and Coordination

9B Chapter

1 SENSORY RECEPTION AND PROCESSING

- **Sensory organs detect all types of changes in the environment**

Sensory receptors (*Detect stimuli*) → Input → CNS (*Process & analyse*) → Output → **Parts/ Organs** (*Response to stimuli*)

2 SENSE ORGANS

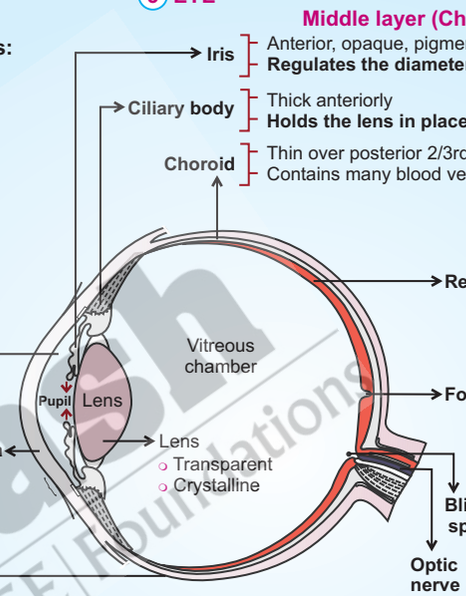
Sense organ	Sense	Features associated
Nose (single)	Smell	❍ Mucus coated **olfactory epithelium** having three types of cells ❍ Neurons extend directly into bean sized **olfactory bulb** that are extensions of limbic system.
Tongue (single)	Taste	❍ Input from **taste buds** is conveyed to the brain and a complex flavour of food or drink is perceived
Ear (paired)	Hearing, balance	❍ Input from organ of Corti and vestibular apparatus is conveyed to CNS.
Eye (paired)	Vision	❍ Enclosed in sockets of skull **(orbits)** ❍ Nearly spherical in structure

❍ The chemical senses of **gustation** (taste) and **olfactory** (smell) are functionally similar and inter related as they detect **dissolved** chemicals.

3 EYE

❍ The **wall** of the eyeball is composed of **three layers:**

- External
- Middle
- Inner



Middle layer (Choroid)

- **Iris** – Anterior, opaque, pigmented, visible coloured portion of the eye. **Regulates the diameter of pupil through its muscle fibres**
- **Ciliary body** – Thick anteriorly. **Holds the lens in place through ligaments**
- **Choroid** – Thin over posterior 2/3rd part. Contains many blood vessels and looks bluish

Inner layer (Retina)

- Outer – Photoreceptor cells **Types: Rods & cones**
- Middle – Bipolar cells
- Inner– Ganglion cells

- Only cones are densely packed
- Thinned central portion of retina
- **Point with greatest visual acuity or resolution**

- Lies medial to and slightly above posterior pole of eye ball
- **No rods or cones here**
- Retinal blood vessels enter
- Optic nerve leaves the eye

❍ **Macula lutea** – Yellowish pigmented spot lying at the posterior pole of eye lateral to the blind spot with a central pit called **fovea**.

Photoreceptor cells	Vision	Photopigments (light sensitive proteins)
Rods	Twilight/Scotopic vision	Rhodopsin/ Purplish red protein/**visual purple**
Cones	Day light/ Photopic vision and Colour vision	**Types of cones** Red, Green, Blue ❍ Different photopigments in these cones ❍ Sensation of different colours by various combinations ❍ **Equal stimulation of these gives sensation of white light**

❍ **Photopigments contain an aldehyde of vitamin A/retinal and protein, opsin.**

4 CHAMBERS IN EYE

	Between		Between	
Cornea	↔	**Lens**	↔	**Retina**
	↓		↓	
	Aqueous chamber		**Vitreous chamber**	
Contains	↓		↓	
	Aqueous humor		Vitreous humor	
Appearance	↓		↓	
	Thin watery fluid		Transparent gel	

5 MECHANISM OF VISION

Visible light rays → (Enter) Cornea → Lens → (Focusses light rays) Photo sensitive cells → (Contain) Rhodopsin dissociates into Opsin (change in structure) + Retinal → (Change in membrane permeability) Generate potential difference in photoreceptor cells → (transmitted to) Bipolar cells → (Generate action potential sent forward to) Ganglion cells → (Impulse) Optic nerve → **Visual cortex**

❍ *Brain analysed image formed on retina based on earlier memory and experience*

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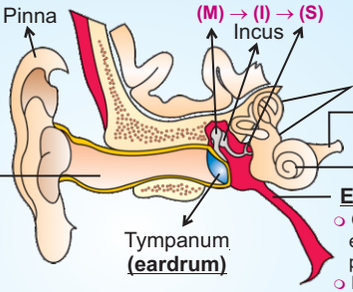
6 THE EAR

Anatomical Divisions → **Outer Ear** (Pinna + Ear canal) → **Middle Ear** (Malleus, Stapes) → **Internal Ear** (Labyrinths)

Components:
- Fine hair and wax glands are present in their skin
- Pinna gathers/collects the vibrations in the air



Eustachian tube
- Connects middle ear cavity to the pharynx
- Equalises pressure on either side of tympanum

- **Tympanic membrane** is composed of → **(a)** Connective tissue covered with skin on the outside; **(b)** Mucus membrane on the inside
- **Ear ossicles** → Arranged in a chain (M → I → S)
  - **Structural details** → Malleus is attached to tympanum; Stapes is attached to the oval window
  - **Function** → **Increase efficiency of transmission of sound waves to the inner ear**

9 MECHANISM OF HEARING

- **Ear converts sound waves into neural impulses**
- The **cerebellum** integrates information received from the semicircular canals of the ear and the auditory system.

Sound waves → Received by → External ear → (extends inwards) → Ear drum → (Vibrations transmitted through) → Ear ossicles → (Transmits vibrations to) → Oval window → (Generate waves in) → Perilymph → (Induce) → Ripples in the basilar membrane → (Bend) → Hair cells of cochlea against tectorial membrane → (Generates impulses in) → Afferent neurons → (transmitted further to) → Auditory nerve → (Transmit impulse to) → **Auditory cortex** [Impulse is analysed and sound is recognised]

7 LABYRINTH

- It is a **fluid filled** inner ear, consists of two parts: **Bony and Membranous labyrinths**
- Bony Labyrinth (**filled with perilymph**) → Encloses → Membranous Labyrinth (**filled with endolymph**)

Parts of Membranous labyrinth	Sub-parts	Receptors	Basic functions
Vestibular apparatus (complex system)	**(a)** Semicircular canals **(3)** **(b)** Otolith organ (Utricle, Saccule)	Crista ampullaris Macula	Maintenance of balance of the body and posture. Influenced by gravity and movements
Cochlea (coiled appearance)		Sensory hair cells in organ of Corti	Hearing

- Semicircular canals lie at right angle to each other and the base of each canal is swollen called **ampulla**.
- These membranous canals are suspended/surrounded by perilymph of the bony canals
- Vestibular apparatus is present above the coiled cochlea.
- **Receptors present in vestibular apparatus have hair cells.**

8 COCHLEA

Demarcating membrane	Chambers	Fluid present within	Terminating region
Reisnner's	**Scala vestibuli**	Perilymph	Oval window
Basilar	**Scala media**	Endolymph	
	Scala tympani	Perilymph	Round window

Organ of Corti
- Located on **Basilar membrane**
- Contains **sensory hairs** present in rows on internal side of organ of Corti, that act as **auditory receptors**.

- Sensory hair cells
  - **Apical part** – Possess **stereocilia**
  - Above them there is thin elastic membrane called **Tectorial membrane**
  - **Basal part** – Is in close contact with **afferent nerve** fibres forming the **auditory nerve**

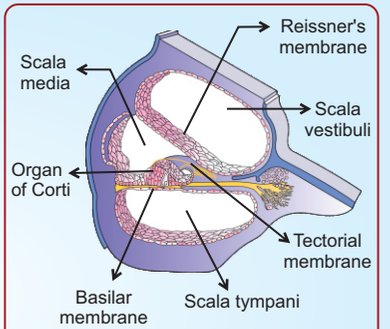


Fig.: Sectional view of cochlea

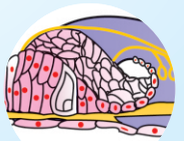


Fig.: Sectional of organ of Corti

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Sharpen Your Understanding

1. Which one of the following is **odd one** w.r.t. retina? [NCERT Pg. 324]
   (1) Macula lutea (2) Fovea
   (3) Blind spot (4) Crista
2. Cells of retina that are specialized to transduce light signals to electric signals are [NCERT Pg. 324]
   (1) Bipolar cells (2) Ganglionic cells
   (3) Cones and rods (4) Glial cells
3. Which of the given fluid in cochlea induces a ripple in basilar membrane? [NCERT Pg. 327]
   (1) Blood (2) Perilymph
   (3) Endolymph (4) Intracellular fluid
4. Maximum number of cones are present in [NCERT Pg. 324]
   (1) Blind spot (2) Fovea
   (3) Pupil (4) Optic nerve
5. Reissner's membrane is present between which of the following cavities or membranes? [NCERT Pg. 326]
   (1) Middle ear and inner ear
   (2) Scala media and scala tympani
   (3) Scala media and scala vestibuli
   (4) Scala tympani and scala vestibuli
6. How many of the following inputs are received and integrated in the midbrain? [NCERT Pg. 328]
   a. Tactile
   b. Auditory
   c. Visual
   (1) a, b only (2) b, c only
   (3) a, c only (4) a, b and c
7. Neurons of olfactory epithelium extend from external environment directly into the olfactory bulbs. These bulbs are an extension of [NCERT Pg. 323]
   (1) Thalamus (2) Cerebrum
   (3) Limbic system (4) Midbrain
8. Vestibular apparatus helps in maintaining body balance and posture as it senses [NCERT Pg. 326]
   (1) Internal movement influenced by stress
   (2) Movement influenced by gravity
   (3) Increasing pitch of sound
   (4) Sound production
9. Basilar membrane is in contact above and below with which fluid respectively? [NCERT Pg. 326]

	Below	Above
(1)	Endolymph	Perilymph
(2)	Perilymph	Perilymph
(3)	Endolymph	Endolymph
(4)	Perilymph	Endolymph

10. The diameter of pupil is regulated by [NCERT Pg. 327]
    (1) Ciliary body
    (2) Iris muscle fibres
    (3) Lens itself
    (4) Ligaments attached to ciliary body

NCERT Based MCQs

11. What would be the **correct** sequence of path followed by light when it falls on eye and the impulse generated? [NCERT Pg. 324]
    (a) Visual cortex (b) Cornea
    (c) Vitreous humor (d) Lens
    (e) Aqueous humor (f) Retina
    (1) b – c – d – e – f – a
    (2) b – e – d – c – f – a
    (3) a – f – b – e – d – c
    (4) d – b – a – c – e – f
12. Select the part of the ear where sound is transduced. [NCERT Pg. 326]
    (1) Tympanic membrane
    (2) Semicircular canal
    (3) Ear ossicles
    (4) Organ of Corti
13. A molecule cannot be tasted or smelled until it has been [NCERT Pg. 323]
    (1) Converted into a neurotransmitter
    (2) Converted into a peptide/protein
    (3) Converted into multi molecular complex
    (4) Dissolved in a liquid
14. The sensory information for hearing is finally interpreted in [NCERT Pg. 327]
    (1) Basilar membrane
    (2) Organ of Corti
    (3) Auditory cortex of brain
    (4) Olfactory part of the brain

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15. Select the **incorrect** statement [NCERT Pg. 324]
(1) Scotopic vision is the function of rods
(2) Rods are present in abundance at the blind spot
(3) Fovea is densely packed with cones
(4) Visual cortex is the area where image formed on the retina is recognized

16. Complete the analogy:
Aqueous humor : Watery fluid
Vitreous humor : [NCERT Pg. 324]
(1) Transparent fluid (2) Transparent gel
(3) Opaque gel (4) Opaque colloid

17. Select the option that **correctly** arranges, the sequence of travel of sound waves in the ear.
(a) Fenestra ovalis (b) Tympanum
(c) Middle ear (d) Fenestra rotunda
(e) Scala tympani (f) Scala vestibuli
[NCERT Pg. 327]
(1) b – c – a – f – e – d
(2) b – c – d – f –e – a
(3) b – c –f – a – e – d
(4) b – c – d – a – e – f

18. Different types of cones possess their own characteristic photopigment that respond to specific wavelength of light. Upon equal stimulation of the cones, the sensation of light produced is of which colour? [NCERT Pg. 324]
(1) Black (2) White
(3) Green (4) Orange

19. Rhodopsin or visual purple contains a derivative of which of the following vitamin/s? [NCERT Pg. 324]
(1) E and K (2) B complex
(3) A and C (4) A

20. Bipolar cells of retina are arranged closely between A and B respectively. [NCERT Pg. 324]

A	B
(1) Rods	Cones
(2) Photoreceptors	Choroid
(3) Photoreceptors	Ganglionic cells
(4) Ganglionic cells	Optic nerve

Thinking in Context

1. Internal ear is responsible for _____ and _____. [NCERT Pg. 326 & 327]
2. Cones are photoreceptors and are responsible for providing _____ vision. [NCERT Pg. 324]
3. The space between cornea and lens is called _____. [NCERT Pg. 324]
4. Image formed on retina is recognized by _____ area of brain. [NCERT Pg. 325]
5. Vestibular apparatus consists of X and Y organ. [NCERT Pg. 326]
6. _____ is the site for sharpest vision in eye. [NCERT Pg. 324]
7. _____ integrates information received from the semicircular canals of the ear and the auditory system. [NCERT Pg. 328]
8. With each taste of food or sip of drink, the brain integrates the differential inputs from the _____ and a complex flavour is perceived. [NCERT Pg. 323]
9. _____ forms the roof of scala media in human ear. [NCERT Pg. 326]
10. Olfactory membrane have _____ receptors. [NCERT Pg. 323]
11. Tympanic membrane is composed of A outside and B inside [NCERT Pg. 325]
12. Visible coloured portion of eye is known as _____. [NCERT Pg. 324]
13. Tongue detects taste through taste A containing B receptors [NCERT Pg. 323]
14. Ear drum is attached to _____ ear ossicle [NCERT Pg. 325]
15. Eustachian tube connects middle ear cavity with _____. [NCERT Pg. 325]
16. Olfactory receptors are made by _____ tissue. [NCERT Pg. 323]
17. Socket of the skull enclosing eyes are called _____. [NCERT Pg. 323]
18. Ciliary body is the thick part of _____ layer of an eye [NCERT Pg. 323]
19. When three types of cones are stimulated equally, sensation of _____ is produced [NCERT Pg. 324]
20. Twilight vision is a function of X and is also called Y vision [NCERT Pg. 324]

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Chemical Coordination and Integration

10 Chapter

1 INTRODUCTION

- **Significance** : As the nerve fibres do not innervate all cells of the body and the cellular functions require continuous regulation, hence the role of endocrine system is integrated with neural system.

2 ENDOCRINE GLANDS AND HORMONES

Endocrine glands (Ductless) glands —secrete→ Hormones

Endocrine glands —form→ Endocrine system & Neural system

Together regulate physiological functions in the body

Endocrine system → Invertebrates (few hormones); Vertebrates (many hormones)

HORMONES

- Released into blood and transported to target organ
- Non-nutrient chemicals
- Act as intercellular messengers
- Produced in trace amounts

3 HUMAN ENDOCRINE SYSTEM

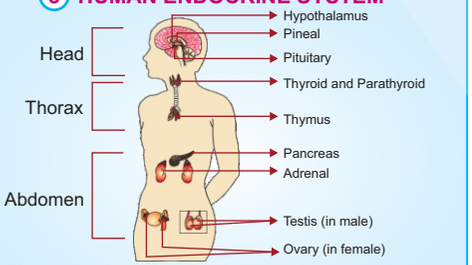


Fig. : Location of endocrine glands

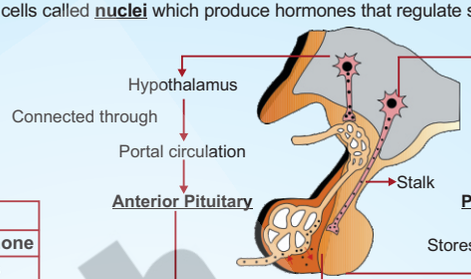
- **Other organs with diffused tissues and cells:** gastrointestinal tract, heart, liver and kidneys

5 PINEAL GLAND

- **Location:** Dorsal side of forebrain
- **Hormone released:** Melatonin
- **Basic functions:**
  - Regulate 24 hours diurnal rhythm of our body (sleep wake cycle)
  - Influence body metabolism, temperature, pigmentation, menstrual cycle and defense capabilities

4 HYPOTHALAMUS AND PITUITARY GLAND

- Hypothalamus contains several groups of neurosecretory cells called **nuclei** which produce hormones that regulate synthesis and secretions from pituitary gland enclosed in bony cavity, **Sella tursica**.



TYPES OF HYPOTHALAMIC HORMONES

	Example	Target	Released hormone
Releasing hormone	GnRH	Pituitary	Gonadotrophins
Inhibiting hormone	Somatostatin	Pituitary	×

Pars distalis | Pars intermedia [Merged in humans] | Pars nervosa

Pars distalis → Adenohypophysis

Pars nervosa → Neurohypophysis

Hormones of Pituitary	Basic function
Growth hormone (GH)	Growth of body
Thyroid stimulating hormone (TSH)	Synthesis and secretion of thyroid hormones by thyroid gland
Adrenocorticotropic hormone (ACTH)	Synthesis and secretion of steroid hormones from adrenal cortex
Follicle stimulating hormone (FSH)	Male – Regulates spermatogenesis along with androgens Female – Stimulates growth and development of ovarian follicles
Gonadotrophins (stimulate gonadal activity)	
Luteinising hormone (LH)	Male – Stimulates the synthesis and secretion of androgens Female – Induces ovulation of fully mature Graafian follicle, maintains corpus luteum
Prolactin	Regulates the growth of the mammary glands and formation of milk in them
Melanocyte stimulating hormone (MSH) by pars intermedia	Acts on the melanocytes of skin and regulates pigmentation of skin

Hormones released	Basic functions
Oxytocin	❍ Acts on smooth muscles and stimulates their contraction ❍ Stimulates vigorous contractions of uterus at the time of child birth ❍ Milk ejection from mammary glands
Vasopressin/ADH/ Anti-diuretic hormone	❍ Acts at kidney and stimulates resorption of water and electrolytes by the distal tubules ❍ Reduces loss of water through urine **(Diuresis)**

ACROMEGALY

Serious complications of hypersecretion of GH in middle age can leads to premature death if unchecked. The disease is hard to diagnose in early stages and often goes undetected for many years, until changes in external features become noticeable.

DISORDERS

Disease	Age	Cause	Symptoms
Pituitary dwarfism		Hyposecretion of GH	Stunted growth
Gigantism		Hypersecretion of GH	Abnormal growth of the body
Acromegaly	Middle age	Hypersecretion of GH	Severe disfigurement especially of face
Diabetes insipidus	–	Hyposecretion of ADH	Diminished ability of the kidney to conserve water leading to water loss and dehydration

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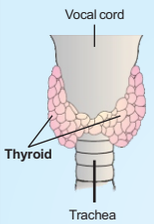
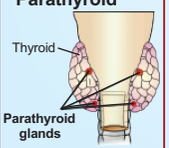
6 GLANDS OF THORACIC REGION

	Location/Feature	Number	Hormones	Basic functions
Thyroid 	○ Side of trachea ○ **Bilobed structure** connected through a thin flap of connective tissue called **isthmus** ○ Consists of **follicles** made up of follicular cells enclosing a cavity, in stromal tissue • **Iodine is essential for the normal rate of hormone synthesis in the thyroid gland**	1	T_4 (thyroxine) or tetraiodothyronine T_3 (triiodothyronine)	○ Regulate basal metabolic rate (**BMR**) ○ Control metabolism of carbohydrates, proteins and fats. ○ Maintain water and electrolyte balance ○ Regulate development and maturation of CNS ○ Support process of RBC formation (**erythropoiesis**) and regulates menstrual cycle
			Thyrocalcitonin (TCT) (**Protein** hormone)	Regulates blood Ca^{+2} levels
Parathyroid 	○ Back side of the thyroid gland • **Thyrocalcitonin and parathormone play a significant role in calcium homeostasis**	4	Parathyroid hormone/ PTH (**peptide** hormone)	○ Increase level of Ca^{+2} (**hypercalcemic**) ○ Acts on bones and stimulates the process of bone resorption (**dissolution/ demineralisation**) ○ Stimulates the reabsorption of Ca^{+2} by the renal tubules. ○ Increases Ca^{+2} absorption from digested food.
Thymus	○ **Lobular structure** located between lungs behind sternum on ventral side of aorta • **Degenerates in old age so immune responses become weak**	1	Thymosins (**peptide** hormones)	○ Play a role in differentiation of T-lymphocytes, thus provide **cell mediated immunity** ○ Promote production of antibodies thereby providing **humoral immunity**.

8 ADRENAL GLAND

○ **One pair** located on anterior part of kidneys

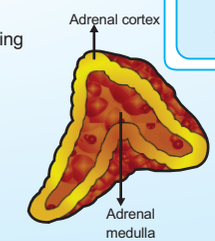
Adrenal gland

Adrenal cortex

	Hormone	Functions
Zona glomerulosa (outer most layer)	Main Glucocorticoid is **cortisol**	○ Stimulates gluconeogenesis, lipolysis and proteolysis ○ Inhibit cellular uptake and utilisation of amino acids, maintains the cardiovascular system and the kidney functions ○ Produces anti-inflammatory reactions and suppresses immune response ○ Stimulate glomerular filtration rate ○ Stimulate RBC production
Zona fasciculata (middle layer)	Major Mineralocorticoid is **aldosterone**	○ Stimulates reabsorption of Na^+ and H_2O and excretion of K^+ and PO_4^- ions, thus helps in maintenance of electrolytes, body fluid volume, osmotic pressure and blood pressure.
Zona reticularis (inner layer)	Androgenic steroid	○ Play a role in growth of axial hair, pubic hair and facial hair during puberty.

Adrenal medulla (Centrally located)

Adrenaline/epinephrine **Nor-adrenaline/nor-epinephrine or Catecholamines** or Emergency/fight/flight hormones	○ Increase alertness, pupilary dilation, piloerection, sweating ○ Increase heart beat, the strength of heart contraction and the rate of respiration ○ Stimulate breakdown of glycogen resulting in an increased concentration of glucose in blood. ○ Increase breakdown of lipids and proteins



7 DISORDERS OF THYROID GLAND

○ **Hypothyroidism**

Cause

• Iodine deficiency in diet during pregnancy and after birth

1. **Goitre:** Enlargement of thyroid gland
2. **Cretinism:** Stunted growth, mental retardation, low intelligence quotient abnormal skin and deaf-mutism
3. In adult women, menstrual cycle can become irregular

○ **Hyperthyroidism**

Cause

• Cancer of the thyroid gland
• Development of nodules of the thyroid gland

1. **Exopthalmic goitre or Graves' disease:**
   • Enlargement of thyroid gland
   • Protrusion of eyeballs
   • Increase in BMR and weight loss.

9 PANCREAS

Pancreas: A **composite** gland whose main hormones **maintain glucose homeostasis**

- Endocrine part
  - 1 to 2 million **Islets of Langerhans** (1-2% of pancreatic tissue)
    - Major cells
      - α-cells → **Glucagon**
      - β-cells → **Insulin**
- Exocrine part

Secretes peptide hormones

	Glucagon	Insulin
○ **Target**	Hepatocytes	Hepatocytes, Adipocytes
○ **Stimulates**	Glycogenolysis, gluconeogenesis	Glycogenesis
○ **Blood glucose level**	↑ (**Hyperglycemic**)	↓ (**Hypoglycemic**)
○ **Glucose** uptake and utilisation by cells	↓	↑

DISORDER

○ **Diabetes mellitus** – Caused by prolonged hyperglycemia
Characteristics – Loss of glucose in urine, Ketone bodies formation
Treatment – Insulin therapy

Disorder	Cause	Characteristic
Addison's disease	Underproduction of hormones of adrenal cortex	Alters carbohydrate metabolism causing acute weakness and fatigue

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10 GONADS → Primary sex organs: Form gametes and secrete hormones

Parameter	Male (Testis)	Female (ovary)
Location	Scrotal sac (outside abdomen)	in abdomen
Structure responsible	Leydig cells/ interstitial cells	Ovarian follicles and corpus luteum
Steroid hormone	Androgens mainly **testosterone**	**Estrogen** / **Progesterone**

Function

- Development and maturation of male accessory sex organs.
- Stimulate spermatogenesis
- Acts on CNS and influence male sexual behaviour (**libido**)
- Stimulate muscular growth, growth of facial and axillary hair, aggressiveness and low pitch of voice.
- Produce **anabolic** (synthetic) effects on protein and carbohydrate metabolism

Estrogen

- Growth and activities of female secondary sex organs
- Stimulate development of growing follicles
- Regulate sexual behaviour
- Appearance of secondary sex characters like mammary gland development, high pitch etc.

Progesterone

- Supports pregnancy
- Stimulates formation of alveoli (store milk and milk secretion

11 HORMONES OF HEART, KIDNEY AND GASTROINTESTINAL TRACT

Tissue	Organ	Hormone	Basic function
Atrial wall	Heart	ANF	When blood pressure increases, it dilates blood vessels to reduce blood pressure.
Juxtaglomerular cells (JG cells)	Kidney	Erythropoietin	Stimulates **erythropoiesis**
Endocrine cells in different parts of gastro-intestinal tract	GIT	Gastrin	Acts on gastric glands and stimulates secretion of HCl and pepsinogen
		GIP/gastric inhibitory peptide	Inhibits gastric secretions and motility
		Cholecystokinin	Acts on exocrine part of pancreas and gall bladder to stimulate secretion of pancreatic enzymes and bile juice
		Secretin	Acts on exocrine part of pancreas and stimulates secretion of water and bicarbonates
Non-endocrine tissue		Growth factors	Essential for normal growth, repair and regeneration of tissues

All these given hormones are peptide hormones.

12 MECHANISM OF HORMONE ACTION

- Hormone receptors are located in the target tissue only
- Each receptor is specific to one hormone only
- Most intracellular receptors are present in the nucleus
- Steroid hormones and iodothyronines enter the target cell
- Hormones acting through extracellular receptors do not enter the target cell

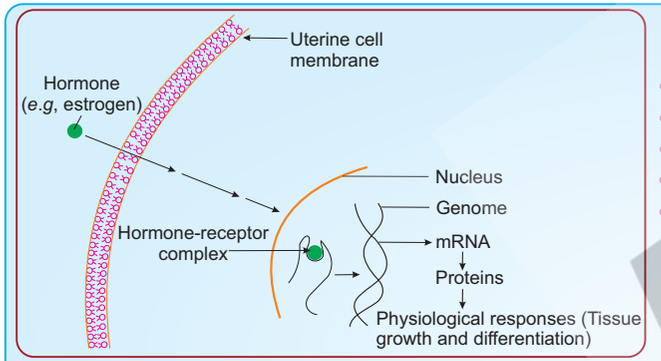

Fig: Mechanism of action of a steroid hormone

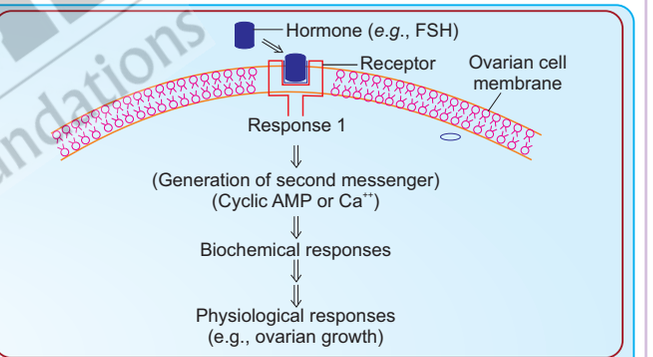

Fig: Mechanism of action of a protein hormone

Classification of Hormones

Based on chemical nature

Steroids – Cortisol, testosterone, estradiol, progesterone
Iodothyronines – Thyroid hormones
Bind to
Intracellular/Nuclear receptors

Amino acid derivatives – Epinephrine
Peptide, Polypeptide, Protein – Insulin, glucagon, pituitary and hypothalamic hormones etc.
Bind to
Extracellular/Membrane bound receptors

Interact with: Genome and regulate gene expression and chromosome functions

Hormone receptor complex

Generate: Second messengers cAMP, IP_3, Ca^{+2} etc

- Brings biochemical changes in target tissue

Cumulative effect

Results in physiological and developmental effects

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Sharpen Your Understanding

1. How many of the given hormones play a significant role in calcium balance in the body? [NCERT Pg. 335]

   a. Parathormone b. Thyrocalcitonin
   c. Thymosin d. Thyroxine

   (1) a and c (2) b and c
   (3) c and d (4) a and b

2. Select the **incorrect** one w.r.t. cortisol [NCERT Pg. 337]

   (1) Anti-inflammatory response
   (2) Suppress RBC production
   (3) Suppress immune response
   (4) Anti-allergic hormone

3. Hormones can be described by all the given features **except** [NCERT Pg. 331]

   (1) Non-nutrient chemicals
   (2) Produced in traces
   (3) Act as intercellular messenger
   (4) Always work by suppressing gene expression

4. Read the following features in a baby and choose the disorder in which they are well observed? [NCERT Pg. 335, 336]

   a. Abnormal skin
   b. Low intelligence quotient
   c. Deaf-mutism
   d. Stunted growth
   e. Mental retardation

   (1) Cretinism
   (2) Graves' disease
   (3) Exophthalmic goitre
   (4) Simple goitre

5. Which one is **not** a secondary messenger? [NCERT Pg. 340]

   (1) IP_3 (2) Ca^{+2}
   (3) cAMP (4) ATP

6. Select the iodine containing hormone [NCERT Pg. 334, 340]

   (1) Cortisol (2) Thyroxine
   (3) Adrenaline (4) Glucagon

7. Which is **not** the exact function of insulin hormone? [NCERT Pg. 337]

   (1) Promote synthesis of fat from glucose
   (2) Target tissues are liver and muscles
   (3) Increase glycogen content in liver and muscles
   (4) Stimulate protein breakdown

8. Which of the following **cannot** be included in the same chemical group? [NCERT Pg. 340]

   (1) Cortisol
   (2) Estradiol
   (3) Progesterone
   (4) Epinephrine

NCERT Based MCQs

9. Which of the given hormone binds with extracellular membrane receptors? [NCERT Pg. 340]

   (1) FSH (2) Estrogen
   (3) Aldosterone (4) Progesterone

10. Anatomically pars distalis and pars intermedia are together included in [NCERT Pg. 333]

    (1) Neurohypophysis
    (2) Adenohypophysis
    (3) Posterior lobe of pituitary
    (4) Anterior lobe of hypothalamus

11. Which of the given disorder is **not** related with growth hormone? [NCERT Pg. 333]

    (1) Acromegaly (2) Dwarfism
    (3) Gigantism (4) Graves' disease

12. How many of the following conditions given can result in goitre? [NCERT Pg. 334, 335]

    a. Hyposecretion of thyroxine
    b. Hypersecretion of thyroxine
    c. Excess iodine in blood
    d. Less iodine in diet

    (1) One
    (2) Two
    (3) Three
    (4) Four

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13. Select the **mismatch** of hormone and its site of action [NCERT Pg. 332]
    (1) Melanocyte stimulating hormone – Skin cells
    (2) Adrenocorticotrophic hormone – Adrenal cortex
    (3) Follicle stimulating hormone – Ovary
    (4) Gonadotrophin releasing hormone – Gonads

14. Which of the following gland grow to the maximum size uptil puberty and then degenerates gradually? [NCERT Pg.335]
    (1) Pituitary (2) Thyroid
    (3) Thymus (4) Parathyroid

15. When blood glucose level drops below the set point, the release of which hormone promotes the release of glucose in blood? [NCERT Pg. 337]
    (1) Insulin (2) Somatostatin
    (3) Glucagon (4) Parathormone

16. Complete the analogy w.r.t. hormone responsible for sexual behaviour.
    Male : Androgens
    Female : X [NCERT Pg. 339]
    (1) Progesterone (2) Estrogen
    (3) Prolactin (4) Cortisol

17. Which hormone is produced by pituitary gland to regulate basal metabolic rate of a child? [NCERT Pg. 332]
    (1) TSH (2) GH
    (3) Thyroxine (4) Somatostatin

18. Which of the following hormone triggers ovulation and stimulates conversion of ovarian follicles into corpus luteum? [NCERT Pg. 338]
    (1) Progesterone (2) LH
    (3) TSH (4) Estrogen

19. Match the columns and select the **correct** option [NCERT Pg. 339]

Column-I	Column-II
a. Gastrin	(i) Inhibits gastric secretion
b. Gastric inhibitory peptide (GIP)	(ii) Stimulates secretions of pancreatic juice
c. Secretin	(iii) Stimulates secretion of water and bicarbonate from pancreas
d. Cholecystokinin (CCK)	(iv) Stimulates secretion of HCl

    (1) a(ii), b(iii), c(i), d(iv)
    (2) a(iv), b(i), c(iii), d(ii)
    (3) a(ii), b(i), c(iii), d(iv)
    (4) a(i), b(ii), c(iv), d(iii)

20. Choose the **mismatch** [NCERT Pg. 338-339]
    (1) Progesterone – Maintenance of pregnancy and development of mammary glands
    (2) Erythropoietin – Secreted by bone marrow and stimulates erythropoiesis
    (3) Estrogen – Stimulates growth and activities of secondary sex organs in female and development of growing ovarian follicles
    (4) Growth factors – Secreted by non-endocrine tissue and are essential for repair and regeneration of tissues

Thinking in Context

1. The neural and _____ system jointly coordinate and regulate the physiological functions in the body. [NCERT Pg. 331]
2. In humans, MSH is secreted by _____. [NCERT Pg. 333]
3. Bony cavity called _____ in a skull bone encloses pituitary gland. [NCERT Pg. 333]
4. _____ pair of parathyroid glands are present on the back side of each lobe of thyroid gland [NCERT Pg. 335]
5. Hormone responsible for anti-diuresis is _____. [NCERT Pg. 334]
6. A peptide hormone named _____ plays a major role in the differentiation of T-lymphocytes. [NCERT Pg. 335]

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7. _____ hormone regulates diurnal rhythm of our body. [NCERT Pg. 334]

8. Underproduction of hormones of adrenal cortex, results in alteration in carbohydrate metabolism that leads to _____ disease [NCERT Pg. 336]

9. _____ is the main mineralocorticoid in our body. [NCERT Pg. 337]

10. Middle layer of adrenal cortex is called _____. [NCERT Pg. 337]

11. _____ hormone plays a major role in the muscular growth and low pitch of voice in males. [NCERT Pg. 338]

12. _____ hormones are rapidly secreted in response to short term stress. [NCERT Pg. 336]

13. Endocrine gland present on either side of trachea is _____. [NCERT Pg. 334]

14. Hyperglycemic hormone produced by α-cells of islets of Langerhans is _____. [NCERT Pg. 337]

15. ANF is a __X__ hormone produced by __Y__ which __Z__ blood pressure. [NCERT Pg. 339]

16. Vigorous contractions of uterus during child birth is due to _____ hormone. [NCERT Pg. 334]

❑ ❑ ❑

17. Diabetes mellitus is due to hypo-secretion of __'A'__ whereas diabetes insipidus is due to hypo-secretion of __'B'__ hormone. [NCERT Pg. 334]

18. Catecholamines secreted by adrenal medulla are _____ and _____. [NCERT Pg. 336]

19. Hormones regulate gene expression by interacting with the genome are _____ and _____. [NCERT Pg. 340]

20. __X__ and __Y__ hormones are synthesized by hypothalamus and are transported axonally to neurohypophysis. [NCERT Pg. 333]

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ANSWERS

Class XI

Chapter-1A : Animal Kingdom: Non-Chordates

Sharpen Your Understanding

1. (1) 2. (3)
3. (1) 4. (2)
5. (2) 6. (3)
7. (2) 8. (2)
9. (1) 10. (1)
11. (4) 12. (3)
13. (4) 14. (2)
15. (1) 16. (2)
17. (4) 18. (2)
19. (2) 20. (2)

Thinking in Context

1. All
2. Bilateral
3. Ectoderm, endoderm, diploblastic
4. Pseudocoelom
5. Acoelomates
6. Externally, internally repetition
7. Food gathering, respiratory exchange, removal of waste
8. Ostia, Spongocoel, Osculum
9. Asexually, sexually
10. Cnidoblast, tentacles, body
11. Eight, ciliated comb plates, locomotion
12. Body surface
13. Plants, animals
14. Muscular pharynx
15. Longitudinal, circular, locomotion
16. Parapodia, swimming
17. Chitinous exoskeleton
18. Mantle, visceral hump
19. Mouth, feeding, radula
20. Radially, bilaterally

Chapter-1B : Animal Kingdom: Chordates

Sharpen Your Understanding

1. (2) 2. (1)
3. (4) 4. (1)
5. (4) 6. (1)
7. (1) 8. (4)
9. (2) 10. (1)
11. (4) 12. (3)
13. (3) 14. (1)
15. (1) 16. (2)
17. (1) 18. (1)
19. (3) 20. (3)

Thinking in Context

1. Marine
2. Urochordata, Cephalochordata
3. 6-15
4. Marine, fresh water
5. Die, after metamorphosis
6. Ventrally, terminal
7. Teeth, backwardly
8. *Torpedo, Trygon*
9. Cartilaginous
10. Head, trunk, Tail
11. Alimentary canal, urinary, reproductive tracts
12. Gills, lungs, skin
13. Dry, cornified, epidermal, scutes
14. Skin cast
15. Oil gland, tail
16. Feathers
17. Beak, wings
18. Hair
19. Crop, gizzard
20. Supplement

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Chapter-2A : Structural Organization in Animals: Animal Tissues

Sharpen Your Understanding

1. (4) 2. (1)
3. (3) 4. (2)
5. (1) 6. (2)
7. (4) 8. (4)
9. (2) 10. (2)
11. (1) 12. (3)
13. (2) 14. (4)
15. (1) 16. (4)
17. (4) 18. (1)
19. (4) 20. (2)

Thinking in Context

1. Function
2. Cilia
3. Goblet
4. Tight
5. Gap
6. Skin
7. Fibroblasts
8. Macrophages
9. Adipose tissue, skin
10. Cartilage, bones, blood
11. Cartilage
12. Calcium salts, collagen fibres
13. Lacunae
14. Skeletal
15. Fluid
16. Myofibrils
17. Communication, intercalated discs
18. Cell junctions
19. Neuroglia
20. Stimulation, inhibition

Chapter-2B : Structural Organization in Animals: Animal Morphology

Sharpen Your Understanding

1. (4) 2. (3)
3. (2) 4. (2)
5. (4) 6. (3)
7. (2) 8. (2)
9. (4) 10. (1)
11. (1) 12. (2)
13. (3) 14. (1)
15. (1) 16. (4)
17. (1) 18. (2)
19. (4) 20. (3)

Thinking in Context

1. ¼, 3, 0.6, 7.6
2. Six, right, neck
3. 7^{th} sternum, 8^{th}, 9^{th} sterna
4. Female gonopore, spermathecal pores, collaterial glands.
5. 9^{th}, 10^{th} terga, 9^{th} sternum
6. Anus, male genital pore, gonapophysis
7. Malpighian tubules, fat body, nephrocytes, uricose glands
8. Glandular, ciliated, nitrogenous, uric acid, hindgut
9. Supra-oesophageal ganglion
10. 2000, Mosaic, sensitivity, resolution
11. 9-10, 14-16
12. Paurometabolus, 13 times
13. Next to last, wing pads, adult,
14. Male gonopore, ventral
15. Eight, common oviduct or vagina
16. Vermicomposting
17. Typhlosole, absorption
18. Aestivation, hibernation
19. 10-12, testes, Bidder's canal
20. 10 pairs

Chapter-3 : Biomolecules

Sharpen Your Understanding

1. (3)
2. (2)
3. (2)
4. (1)
5. (2)
6. (2)
7. (1)
8. (3)
9. (3)
10. (3)
11. (2)
12. (4)
13. (4)
14. (3)
15. (3)
16. (3)
17. (3)
18. (1)
19. (1)
20. (2)

Thinking in Context

1. Carbon, Hydrogen
2. Lipids
3. Water
4. Ecological
5. Primary
6. Lower
7. Non-essential
8. N-acetyl glucosamine, exoskeleton
9. Right
10. Sugar-phosphate-sugar chain
11. 36°
12. Non-equilibrium
13. Uncatalysed
14. Proteins, nucleic acids, ribozymes
15. 6,00,000, every
16. Activation energy
17. Inactive, destroyed
18. Competitive
19. Apo-enzyme
20. Prosthetic, Haem

Chapter-4 : Digestion and Absorption

Sharpen Your Understanding

1. (2)
2. (3)
3. (3)
4. (3)
5. (3)
6. (3)
7. (3)
8. (2)
9. (1)
10. (1)
11. (3)
12. (2)
13. (3)
14. (2)
15. (3)
16. (4)
17. (2)
18. (3)
19. (4)
20. (2)

Thinking in Context

1. Thecodont
2. Hepatic lobule
3. Enterokinase
4. Enamel
5. X -acidic; Y -alkaline
6. Mechanical and chemical
7. Sucrase, fructose, lactase, galactose
8. X = Three, Y = Outside, Z = Buccal cavity
9. Glisson's capsule
10. Defaecation
11. Emulsification
12. Small intestine
13. Pharynx
14. Ileo-caecal valve
15. Neural signals
16. Bile pigments
17. Marasmus
18. Mucus
19. Fat globules coated by protein
20. Vomiting centre in medulla oblongata

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Chapter-5 : Breathing and Exchange of Gases

Sharpen Your Understanding

1. (4)
2. (3)
3. (4)
4. (3)
5. (3)
6. (1)
7. (2)
8. (3)
9. (4)
10. (3)
11. (2)
12. (3)
13. (1)
14. (2)
15. (4)
16. (3)
17. (4)
18. (4)
19. (1)
20. (2)

Thinking in Context

1. Habitats, Level of organizations
2. Elastic cartilaginous, epiglottis
3. 5^{th} thoracic
4. Antero-posterior
5. Increase, lower
6. Spirometer
7. 20-25 times
8. 45 mm Hg and 40 mmHg
9. FRC (Functional residual capacity)
10. Alveoli
11. Reversible
12. Sigmoid
13. 12-16
14. 8
15. Bicarbonates
16. 4 ml
17. Medulla oblongata
18. CO_2, H^+ ions
19. Emphysema
20. Oxygen

Chapter-6 : Body Fluids and Circulation

Sharpen Your Understanding

1. (3)
2. (3)
3. (2)
4. (2)
5. (2)
6. (3)
7. (2)
8. (4)
9. (1)
10. (3)
11. (4)
12. (2)
13. (2)
14. (3)
15. (4)
16. (3)
17. (2)
18. (3)
19. (2)
20. (3)

Thinking in Context

1. Albumin
2. Serum
3. Neutrophils
4. A, B, AB, O
5. Anti-Rh antibodies
   Delivery of the first child
6. Ca^{+2}
7. 120 days
8. Megakaryocytes
9. Left ventricle
10. Fats
11. Dub
12. Stethoscope
13. Coronary vessels
14. Neural and hormonal
15. Right ventricle
16. 30%
17. T
18. Stroke volume
19. 140/90
20. Cardiac

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Chapter-7 : Excretory Products and Their Elimination

Sharpen Your Understanding

1. (1) 2. (3)
3. (4) 4. (4)
5. (2) 6. (4)
7. (2) 8. (2)
9. (3) 10. (4)
11. (2) 12. (3)
13. (3) 14. (2)
15. (1) 16. (3)
17. (4) 18. (2)
19. (3) 20. (2)

Thinking in Context

1. Protonephridia /Flame cells
2. 10-12 cm, 5-7 cm
3. Cooling effect on body surface
4. ADH/vasopressin
5. Collecting duct
6. Urethra
7. Ascending limb of loop of Henle
8. NaCl and urea
9. Malpighian body/renal corpuscle
10. 25-30 gm
11. PCT
12. Micturition
13. Cellophane sheet/tubes of dialyser
14. Relaxed
15. 300-1200 mOsm / L
16. Haemodialysis
17. Peritubular capillaries
18. ANF
19. Four
20. Renin

Chapter-8 : Locomotion and Movement

Sharpen Your Understanding

1. (1) 2. (3)
3. (1) 4. (4)
5. (4) 6. (4)
7. (1) 8. (3)
9. (3) 10. (3)
11. (3) 12. (2)
13. (1) 14. (4)
15. (2) 16. (3)
17. (2) 18. (4)
19. (2) 20. (2)

Thinking in Context

1. Scapula
2. Sarcoplasmic reticulum
3. Fascia
4. Flagellar
5. A-band
6. Meromyosin
7. Dorsal, bicephalic
8. Myasthenia gravis
9. Sarcomere
10. Ventrally
11. 5 metacarpal
12. Synovial
13. Myoglobin
14. Chondroitin salts
15. Actin, ATP
16. Femur
17. Cartilaginous
18. Glenoid
19. Low Ca^{+2}
20. Sternum

Chapter-9A : Neural Control and Coordination

Sharpen Your Understanding

1. (3)
2. (2)
3. (2)
4. (1)
5. (1)
6. (2)
7. (3)
8. (2)
9. (3)
10. (4)
11. (2)
12. (3)
13. (3)
14. (1)
15. (1)
16. (2)
17. (3)
18. (3)
19. (3)
20. (2)

Thinking in Context

1. Coordination
2. Electrical, chemical
3. Brain
4. Gustation (taste), olfactory (smell)
5. Hypothalamus
6. Longitudinal
7. Association
8. Hypothalamus
9. Midbrain, forebrain, hindbrain
10. Medulla oblongata
11. Autonomic
12. Grey
13. Fear and rage
14. Medulla oblongata
15. Schwann
16. Peripheral nervous system
17. CNS (Forebrain)
18. Dorsal
19. Reflex action
20. Cerebellum

Chapter-9B : Neural Control and Coordination

Sharpen Your Understanding

1. (4)
2. (3)
3. (3)
4. (2)
5. (3)
6. (4)
7. (3)
8. (2)
9. (4)
10. (2)
11. (2)
12. (4)
13. (4)
14. (3)
15. (2)
16. (2)
17. (1)
18. (2)
19. (4)
20. (3)

Thinking in Context

1. Balancing, hearing
2. Photopic/daylight
3. Aqueous chamber
4. Visual cortex
5. X-Semicircular canals, Y-Otolith
6. Fovea
7. Cerebellum
8. Taste buds
9. Reissner's membrane
10. Olfactory
11. A – Connective tissues covered with skin
    B – Mucus membrane
12. Iris
13. A – Buds;
    B – Gustatory
14. Malleus
15. Pharynx
16. Epithelial
17. Orbits
18. Middle layer/choroid
19. White light
20. X – Rods
    Y – Scotopic

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Chapter-10 : Chemical Coordination and Integration

Sharpen Your Understanding

1. (4)
2. (2)
3. (4)
4. (1)
5. (4)
6. (2)
7. (4)
8. (4)
9. (1)
10. (2)
11. (4)
12. (3)
13. (4)
14. (3)
15. (3)
16. (2)
17. (1)
18. (2)
19. (2)
20. (2)

Thinking in Context

1. Endocrine
2. Pars intermedia
3. Sella tursica
4. One
5. Vasopressin/ADH
6. Thymosin
7. Melatonin
8. Addison's
9. Aldosterone
10. Zona fasciculata
11. Androgen/testosterone
12. Epinephrine/Norepinephrine
13. Thyroid
14. Glucagon
15. X – Peptide; Y – Atrial wall; Z – Decreases
16. Oxytocin
17. A – Insulin
    B – ADH
18. Adrenaline and noradrenaline
19. Steroid and iodothyronines
20. X-oxytocin; Y-vasopressin

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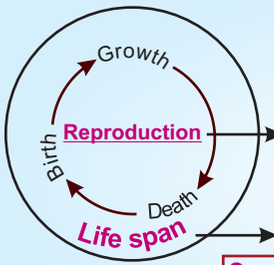
Reproduction in Organisms

Chapter 1

1 INTRODUCTION



Life cycle of an organism

- Process in which an organism gives rise to offspring(s) similar to itself
- Biological process ensuring continuity of species on Earth, generation after generation
- **Mechanism depends on**
  - Organism's habitat
  - Diversity in structure
  - Internal physiology
  - Environmental factors
- Not linked to **size** of organism

Organism	Life span
Butterfly	1-2 weeks
Crow	15 year
Tortoise	100-150 years
Parrot	140 years

- No individual is **immortal** except single-celled organisms.

2 TYPES OF REPRODUCTION

Parameters	Asexual	Sexual
Number of parents	One (uniparental)	One (Uniparental) - *Taenia* or Two (Biparental) - *Periplaneta*
Gamete formation	Yes	Yes
Gamete fusion	**No**	Yes
Type of cell division	Mitotic	Meiotic and mitotic
Conditions for occurrence	Mostly favourable	Both favourable and unfavourable
Nature of offsprings	Identical to parent	Mostly non-identical offsprings
Examples	*Hydra, Planaria*	*Pheretima*
Advantages	• Simple process • Rapid/faster	• Contributes to evolution significantly through genetic recombination • High adaptability
Disadvantages	• No contribution to evolution as genetic recombination/crossing over is absent • Low adaptability	• Complex — Elaborate, Expensive • Slower process

- **Clone:** Morphologically and genetically similar individuals produced asexually.
- **Cell division** is in itself a mode of reproduction in unicellular organisms *e.g.*: *Amoeba*, *Paramecium*.

3 TYPES OF ASEXUAL REPRODUCTION

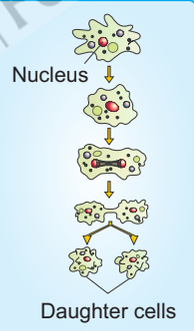
a. Fission

- Process in which an individual forms 2 or more daughter individuals

Types

Parameter	I. Binary fission	II. Multiple fission
Operational conditions	Favourable	Favourable and unfavourable
Number of daughters	2	Multiple
Spindle formation	Yes	No
Example	*Amoeba*	*Amoeba*

Mechanism



Withdrawal of pseudopodia
↓
Encystation (3 layered cyst)
↓
Multiple fission
↓
Excystation
↓
Sporulation

b. Fragmentation

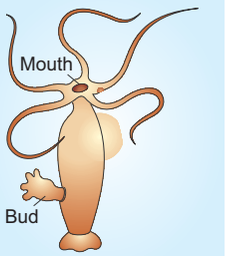
- The body of the organism breaks into distinct pieces/fragments and each fragment grows into an adult capable of producing offsprings
- **Example -** *Hydra*

c. Budding

Types

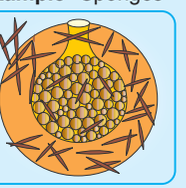
I. External budding

- A small bulge (unequal division) from the parent body that develops externally and eventually separates from the parent
- **Example -** *Hydra*



II. Internal budding

- Internal buds called **gemmules** that are aggregates of archaeocytes protected by spicules.
- **Example -** Sponges



A gemmule

4 PARTHENOGENESIS

- Absence of gamete fusion/syngamy
- Female gamete develops into new organism without fertilisation
- **Examples:** Rotifers, honey bees, some lizards, birds (turkey).

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5 SEXUAL REPRODUCTION

- **Remarkable fundamental similarity** occur in process of sexual reproduction among different organisms **despite different structures** for reproduction.
- Reproductive processes and associated behaviors are regulated by **hormones** and **environmental factors**.

Pre-reproductive Phase: Birth → Juvenile → Puberty

Events associated

A. Pre-fertilisation events: → Gametogenesis, Gamete transfer

a. Gametogenesis: Formation of gametes

- **Meiocytes:** Gamete forming diploid cells/gamete mother cells
- **Gametes are haploid** in nature i.e. receive only one set of chromosomes at the end of meiosis
- A **haploid parent** produces gametes by **mitotic divisions**
- A **diploid parent** produces haploid gametes by **meiosis**

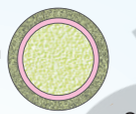
Name of organism	Chromosome number in meiocyte (2n)	Chromosome number in gamete (n)
Humans	46	23
House fly	12	6
Rat	42	21
Dog	78	39
Cat	38	19
Fruit fly	8	4
Butterfly	380	190

Types of gametes (Basis: Morphological and physiological difference)

Heterogametes
- Different

Types

Parameters	Female	Male
Size	Big	Small
Motility	⊖	⊕
Chromosome number	Same	Same
Food storage	⊕	⊖
Number	Less	More



Homogametes/Isogametes
- Same

b. Gamete transfer: Enables bringing together of ♂ and ♀ gametes physically leading to fertilisation.

Internal fertilisation
- Fertilisation occurs inside ♀ reproductive tract
- Mostly terrestrial organisms *e.g.* Reptiles, mammals

External fertilisation
- Fertilisation occurs in water
- Mostly aquatic organisms *e.g.* Bony fishes and amphibians

Disadvantages
- Limited number of progeny
- Offsprings are extremely vulnerable to predators threatening their survival to adulthood

Types of organisms

Bisexual (Hermaphrodite)	Unisexual
Leech	Cockroach
Earthworm	
Sponges	

- Great **synchrony** required between ♀ and ♂ during external fertilisation to enhance chances of fertilisation.
- Heterogametes are present in majority of sexually reproducing organisms.

Reproductive Phase

B. Fertilisation

Most vital event of sexual reproduction is fusion of gametes called **syngamy** resulting in formation of **diploid, single celled structure** → **ZYGOTE**

Vital connecting link ensuring continuity of species between generations.

C. Post-fertilisation

- **Embryogenesis:** Process of development of embryo from the zygote through **mitotic cell divisions** help increase number of cells and **cell differentiation** helps in formation of specialised tissues and organs

Location of development of zygote

Oviparous animals
- Outside the ♀ body
- Protected by calcareous shell
- Lesser parental care

Viviparous animals
- Inside the ♀ body
- Absent
- Greater parental care

The chances of survival of young ones is greater in viviparous organisms

Post-reproductive Phase: Death

- End of reproductive phase is a parameter of senescence
- Slowing of metabolism
- Ultimately leads to death

6 BREEDING SEASON

Basis: The time duration when mating occurs

Parameters	Continuous breeders	Seasonal breeders
Breeding time	Throughout the year	Specific breeding season
Examples	Primates, Hens (poultry birds in captivity)	Elephant, Birds in wild, Horse, Cow, Goat

7 REPRODUCTIVE CYCLES IN PLACENTAL MAMMALS

- Cyclical changes during reproduction

Parameters	Oestrous cycle	Menstrual cycle
Characteristic of	Non-primate mammals	Primates
Examples	Cows, deer, sheep, rats, dogs, tiger	Humans, apes, monkeys

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Sharpen Your Understanding

1. Each and every organism can live for only a certain period of time. This is true for all **except** [NCERT Pg. 3]

   (1) *Psittacula* (2) *Paramecium*

   (3) *Pavo* (4) *Pheretima*

2. A vast number of plant and animal species have existed on earth for several thousand years by virtue of [NCERT Pg. 3]

   (1) Life span

   (2) Regeneration

   (3) Reproduction

   (4) Their sizes

3. Read the statements given below.

   a. The sizes of crow and parrot are not very different.

   b. The life span of fruit fly is much longer than that of a tortoise.

   c. No individual is immortal except multiple-celled organisms.

   Select the **correct** option w.r.t. true and false. [NCERT Pg. 3]

	a	b	c
(1)	T	T	T
(2)	T	F	T
(3)	F	T	T
(4)	T	F	F

NCERT Based MCQs

4. Cell division is in itself considered a mode of reproduction in [NCERT Pg. 6]

   (1) Vertebrates

   (2) All organisms with cell wall

   (3) Unicellular organisms

   (4) Multicellular organisms

5. Generally, gametes in a sexually reproducing organism are different in all given aspects **excluding** [NCERT Pg. 11]

   (1) Amount of cytoplasm

   (2) Motility

   (3) Chromosome number

   (4) Size

6. How many organisms among following are hermaphrodites? [NCERT Pg. 7]

   Ascaris, *Taenia*, *Pheretima*, *Amoeba*, *Periplaneta*, *Paramecium*

   (1) Zero (2) Two

   (3) Three (4) Four

7. As compared to others, cyclical changes during reproduction/reproductive cycle are dissimilar in [NCERT Pg. 9]

   (1) Monkeys (2) Deer

   (3) Rats (4) Tiger

8. Select the option that completes the analogy House fly : 6 : : _____: 19 [NCERT Pg. 13]

   (1) Fruit fly (2) Butterfly

   (3) Dog (4) Cat

9. Chromosome number in gamete of human beings is 23. What is the chromosome number in meiocytes of a rat? [NCERT Pg. 13]

   (1) 21 (2) 42

   (3) 46 (4) 38

10. The event **not** included in category of post-fertilisation events is [NCERT Pg. 15]

    (1) Cell differentiation

    (2) Embryogenesis

    (3) Gamete formation

    (4) Mitotic divisions in zygote

11. Syngamy is **not** observed in life cycle of some animals such as [NCERT Pg.14]

    (1) Cockroach (2) Rotifers

    (3) Earthworm (4) Humming bird

12. Among given options, the fertilized eggs are covered by hard calcareous shell in possibly all **except** [NCERT Pg. 16]

    (1) Honey bee (2) Snakes

    (3) Lizards (4) Turkey

13. The offsprings resulting from sexual reproduction [NCERT Pg. 16]

    (1) Are identical to their parent

    (2) Can be referred to as clones

    (3) Do not offer genetic variations

    (4) Are a result of gamete fusion

14. Asexual reproduction differs from sexual reproduction as [NCERT Pg. 18]
(1) The latter is always biparental
(2) The former is simpler and rapid
(3) The former always requires gamete formation
(4) The latter is never seen in hermaphrodites

15. Which is **correct** in context of multiple fission? [NCERT Pg. 6]
(1) Excystation precedes nuclear divisions
(2) Encystation occurs upon arrival of favourable conditions
(3) Formation of pseudopodiospores occurs prior to arrival of unfavourable conditions
(4) Every nuclear division is not followed by immediate cytoplasmic division

16. Select the **mis-match**. [NCERT Pg. 6]
(1) Internal budding – Sponges
(2) External budding – *Hydra*
(3) Binary fission – *Amoeba*
(4) Multiple fission – *Paramecuim*

17. The umbrella of continuous breeders does **not** include [NCERT Pg. 9]
(1) Birds in wild
(2) Humans
(3) Monkeys
(4) Chimpanzees

18. Read the given statements and select the **correct** option. [NCERT Pg. 9]
(1) An animal is mostly reproductively mature in the juvenile phase
(2) Juvenile phase is of fixed duration in different organisms
(3) Juvenile phase is followed by morphological and physiological changes prior to active reproductive behaviour
(4) The reproductive phase can never be of variable durations in different organisms

19. Which among the following can be made to lay eggs throughout the year (nearly every day)? [NCERT Pg. 9]
(1) Poultry birds (2) Lion
(3) Goat (4) Sheep

20. Both binary fission and multiple fission are observed in which organism depending on environmental conditions? [NCERT Pg. 6]
(1) *Paramecium*
(2) *Amoeba*
(3) *Plasmodium*
(4) *Pheretima*

Thinking in Context

1. A haploid parent produces gametes by _____ division while humans produce gametes by _____ divisions. [NCERT Pg. 11]

2. In majority of sexually reproducing organisms, the gametes produced are of morphologically distinct types, hence called _____ [NCERT Pg. 11]

3. While earthworms, sponges, tapeworm and leech are bisexual animals, cockroach is an example of _____ organism. [NCERT Pg. 11]

4. Gamete formation occurs inside the body even in case of animals exhibiting _____ fertilisation. [NCERT Pg. 14]

5. In many animals, the female gamete undergoes development to form new organisms without fertilisation by a phenomenon known as _____. [NCERT Pg. 14]

6. _____ represents the time period from birth to the natural death of an organism. [NCERT Pg. 3]

7. The life spans of organisms are _____ necessarily correlated with their sizes. [NCERT Pg. 3]

8. The biological process ensuring continuity of species generation after generation on earth is _____. [NCERT Pg. 5]

9. The mortal organisms undergo cyclic events during their life including birth, _____ and death. [NCERT Pg. 5]

10. Method of asexual reproduction involving unequal division and formation of small out growth that initially remains attached to the parent is _____. [NCERT Pg. 6]

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11. If possible, organisms shift to _____ method of reproduction just before the onset of adverse conditions. [NCERT Pg. 8]
12. Cyclical changes observed in reproductive tract of primates are collectively called _____. [NCERT Pg. 9]
13. Many mammals, living in the natural wild conditions exhibit cycles only during favourable seasons in their reproductive phase and are therefore called _____. [NCERT Pg. 10]
14. Changes in the ageing body such as slowing of metabolism are indicative of _____ of the reproductive phase. [NCERT Pg. 10]
15. Component of endocrine system called _____ are responsible for transition from juvenile to reproductive phase and later to post reproductive phase. [NCERT Pg. 10]
16. Gamete formation and gamete _____ are events that occur in pre-fertilisation phase of sexually reproducing organisms. [NCERT Pg. 10]
17. To enhance chances of fertilisation in organisms undergoing mating in water, release of gametes must occur in greatly _____ manner. [NCERT Pg. 14]
18. In _____ organisms, protection and proper embryonic care increases chances of survival of young ones. [NCERT Pg. 16]
19. _____ is the vital link that ensures continuity of species between organisms of one generation and the next. [NCERT Pg. 15]
20. In comparison to animals exhibiting external fertilisation, there is considerable _____ in the number of eggs produced by animals exhibiting internal fertilisation. [NCERT Pg. 15]

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Human Reproduction

2A Chapter

1 INTRODUCTION

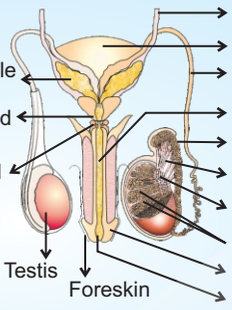
- Humans are sexually reproducing viviparous organisms
- Reproductive system is composed of
  - **Primary sex organs** – Site for gamete formation
  - **External genitalia** – Involved in copulation
- Accessory ducts
- Accessory glands

} Facilitate transport of gametes

2 THE MALE REPRODUCTIVE SYSTEM

- **Location:** Pelvic region
- **Seminal plasma** from these contains fructose, calcium, enzymes
- Its secretions **lubricate the penis**
- Vas deferens receives a duct from seminal vesicle and opens into the urethra as the **Ejaculatory duct**

Accessory glands
- Seminal vesicle (*1 pair*)
- Prostate gland (*one*)
- Bulbourethral gland (*1 pair*)

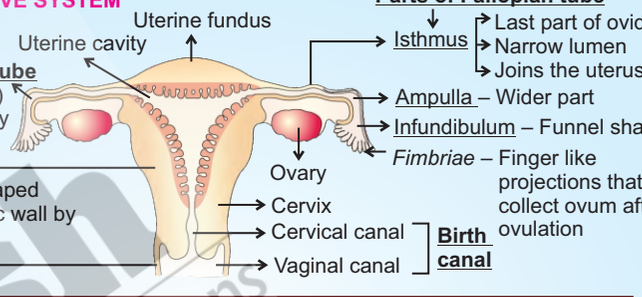


External genitalia of Male/Penis:

Parts	Features
Urethra	Originates from the urinary bladder and extends through the penis
Special tissues	Help in erection of penis to facilitate insemination
Glans penis	Enlarged end of penis covered by loose fold of skin called **foreskin**

3 FEMALE REPRODUCTIVE SYSTEM

- **Location :** Pelvic region



- **Oviduct/fallopian tube**
  - 10-12 cm (length)
  - Extend from ovary to uterus
- **Uterus/womb**
  - Inverted pear shaped
  - Attached to pelvic wall by ligaments
- Vagina

Parts of Fallopian tube
- Isthmus – Last part of oviduct; Narrow lumen; Joins the uterus
- Ampulla – Wider part
- Infundibulum – Funnel shaped
- *Fimbriae* – Finger like projections that collect ovum after ovulation

Birth canal = Cervical canal + Vaginal canal

- **Uterine wall consists of three layers:**
  1. **Endometrium** – Lines lumen, glandular and undergoes cyclic changes during menstruation
  2. **Myometrium** – Thick layer of smooth muscles that show strong contractions during delivery
  3. **Perimetrium** – External thin membrane

External Genitalia of Female:

Parts	Features
Mons pubis	Cushion of fatty tissue covered by skin and pubic hair
Labia majora	Fleshy folds of tissue that extend down mons pubis and surround the vaginal opening
Labia minora	Paired folds of tissue under the labia majora
Clitoris	Tiny finger like structure which lies at the upper junction of labia minora above the urethral opening
Hymen	• Membrane that partially covers the opening of vagina • Can be torn while - sudden jolt/fall, horse riding, cycling, insertion of vaginal tampon. • May or may not be torn during the first coitus so its presence or absence is not reliable indicator of virginity or sexual experience.

4 PRIMARY SEX ORGANS

Parameters	Male	Female
Organ	Testis	Ovary
Number	2	2
Shape	Oval	Almond
Location	Outside abdominal cavity in a pouch called **scrotum**	Lower abdomen, one on each side
Dimensions	Length 4-5 cm, Width 2-3 cm	Length 2 to 4 cm
Covering	Dense connective tissue (outermost)	Thin epithelium (outermost)
Functions	Sperm formation, synthesise steroidal **testicular** hormones like androgens	Ova formation, synthesise steroidal **ovarian** hormones like estrogen and progesterone
Compartments	250 testicular lobules	Peripheral **cortex** and inner **medulla** zones in ovarian stroma have follicles in various developing stages

- 1-3 coiled seminiferous tubules/lobule

Cells lining the seminiferous tubules	Functions
1. Male germ cells/spermatogonia	Sperm formation
2. Sertoli cells	Provide nutrition to the germ cells

- Scrotum helps in maintaining the temperature 2 to 2.5°C lower than body temperature, necessary for **spermatogenesis**.
- Interstitial spaces outside seminiferous tubules contain **immunocompetent** cells and **Leydig cells**
- Ovary is connected to pelvic wall and uterus by **ligaments**.

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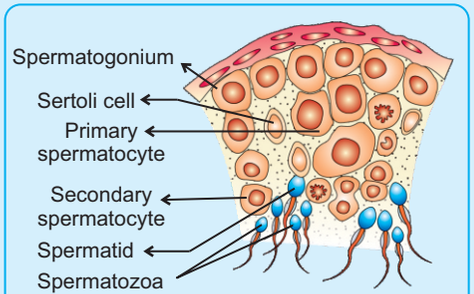


Fig. : Sectional view of seminiferous tubules

5 GAMETOGENESIS

❍ **Process of gamete formation**

Parameters	Male	Female
• **Term**	Spermatogenesis	Oogenesis
• **Process begins**	At puberty	During embryonic development
• **Ploidy & chromosome number per cell**		
2n = 46	Male germ cells/ Spermatogonia	Female mother cells/ Oogonia
	Mitosis & differentiation	
2n = 46	Primary spermatocytes	Primary oocytes
		In **Fetus** (**arrested at prophase I**)
	Periodic Meiosis I	Birth, Puberty
n = 23	Secondary spermatocytes	1st polar body, Secondary oocyte
	Meiosis II	
n = 23	Spermatids	2nd polar body, Ovum
	Spermiogenesis	
n = 23	Sperms	Graafian/ mature → Ovulation
	Spermiation	
	Released from seminiferous tubules	

*2n = diploid
*n = haploid

Follicles: Primary → Secondary → Tertiary → Graafian/ mature → Ovulation

Characteristics

- Single layer of granulosa cells
- More layers of granulosa cells and a **new theca layer**
- Completion of meiosis I (*Reduction division*)
- Fluid filled cavity **antrum** and theca layers are organised into external and internal layers
- Secondary oocyte forms **acellular zona pellucida** around it

❍ No more oogonia are formed and added after birth

❍ A large number of follicles degenerate from birth to puberty so only **60,000-80,000 primary follicles are left in each ovary at puberty**.

❍ **Meiosis** in oogenesis results in **unequal sized cells** and the secondary oocyte retains bulk of the nutrient rich cytoplasm of the primary oocyte

❍ Fate of polar body is not certain

❍ During the embryonic development, a couple of million gamete mother cells (oogonia) are formed within each fetal ovary

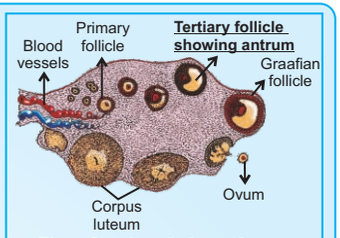


Fig. : Sectional view of ovary

Spermiogenesis is transformation of **spermatids** to sperms and sperm head is embedded in **Sertoli cells**

6 Semen

- Secretions of epididymis and vas deferens are essential for maturation and motility of sperms
- **Male ejaculate**s about 200-300 million sperms during a coitus.
- **For normal fertility :**
  - ❍ 60% sperms must have normal shape and size
  - ❍ **40% of 60% sperms must show vigorous motility**

7 HORMONAL REGULATION IN MALES

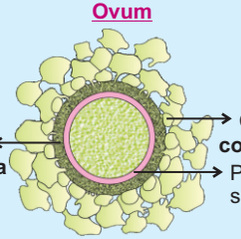
Hypothalamus
↓ secretes
GnRH (significant amount)
↓ targets
Anterior pituitary
↓ secretes
Gonadotropins

FSH	Seminiferous tubules	LH
↓ acts on (Inside)		↓ (Outside)
Sertoli cells		Leydig/interstitial cells
↓ **Synthesise & release**		↓
Some factors		Androgens/Testicular hormones
↓ **Stimulate**		↓
Spermiogenesis		**Spermatogenesis**

❍ The function of male sex accessory ducts and glands are maintained by the testicular hormones (androgens)

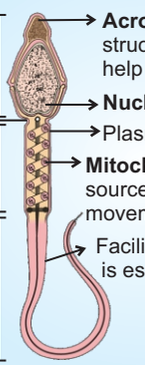
8 STRUCTURE OF GAMETES

Ovum



Sperm

Main parts



- **Acrosome** - cap like structures filled with enzymes, help in fertilization
- **Nucleus (n)** (elongated)
- Plasma membrane
- **Mitochondria**-provide energy source for swimming/ movement of tail
- Facilitate sperm motility which is essential for fertilization

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9 HORMONAL REGULATION IN FEMALES AND MENSTRUAL CYCLE

- The cycle of events starting from one menstruation till the next one is termed **menstrual cycle**
- **Characteristic** of female primates → Monkeys, Apes, Humans
- **Begins** at puberty - **menarche**
- **Ceases** at 50 years - **menopause**

Reproductive phase

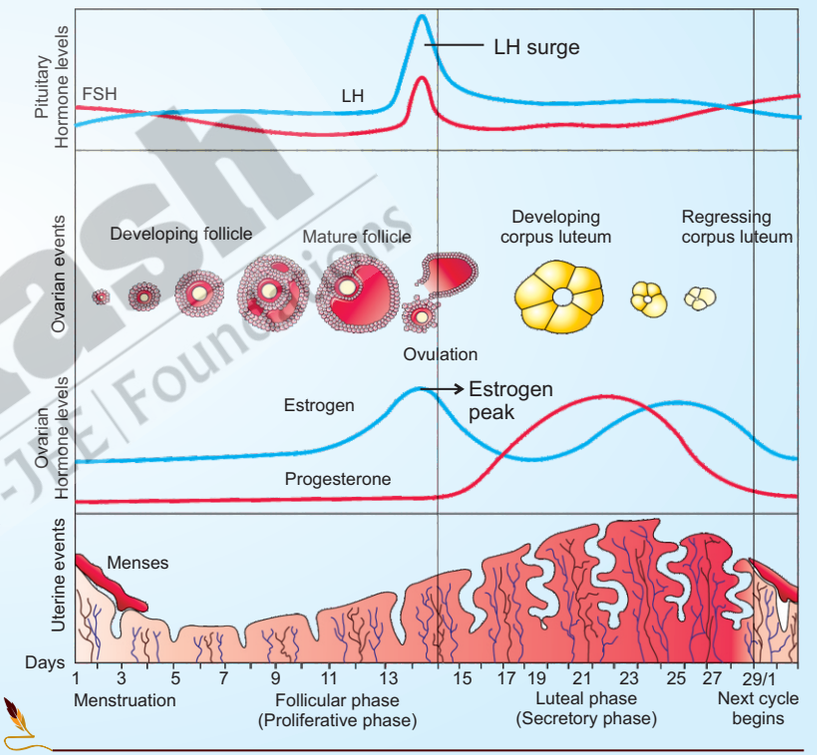
- **Cycle occurs if ovum remains unfertilized**
- **Lack of cycle** may be an indication of
  - Pregnancy, stress, poor health *etc.*
- Average duration in humans = 28/29 days

Menstrual Cycle

- Changes in the ovary and the uterus are induced by changes in the levels of pituitary and ovarian hormones

Reproductive cycle

Phase	Duration	Hormones & their effects	Events in ovary	Events in uterus
Menstrual	3-5 days	Drastic decline in progesterone	Corpus luteum degenerates	• Breakdown of endometrial lining and its blood vessels which forms liquid that comes out through vagina constituting **menstrual flow**
Follicular or Proliferative phase	Variable	Gradual increase in FSH and LH that stimulate secretion of estrogen from follicles	Primary follicle gradually matures to Graafian follicle	• Endometrium regenerates through proliferation
Ovulation	14th day (Middle of cycle)	FSH and LH at peak, **(LH surge)**	Rupture of Graafian follicle and release of only one ovum/ cycle	• Proliferation of endometrium continues
Luteal or Secretory	**Fixed (14 days)**	Secretion of progesterone and estrogen	Remnants of the Graafian follicle transforms into corpus luteum	• Endometrium is maintained • If ovum remains unfertilized, endometrium is sloughed off, marking a new cycle



- **If ovum gets fertilized, endometrium is maintained by progesterone** necessary for implantation and other events of pregnancy.
- During pregnancy all events of menstrual cycle stop

Menstrual Hygiene

1. Maintenance of hygiene and sanitation during menstruation is very important
2. Take bath and clean yourself regularly use sanitary napkins/home made pads
3. Change sanitary pads after every 4-5 hrs.
4. Dispose of used sanitary napkins properly by wrapping it in used paper.
5. After handling the napkin wash hands with soap

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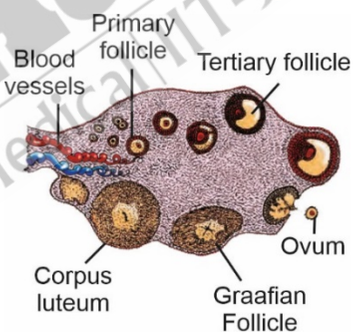
Sharpen Your Understanding

1. Choose the **incorrect** statement w.r.t. primary sex organ in males [NCERT Pg. 43]
   (1) They have immunocompetent cells in their interstitium.
   (2) They bear connection with abdomen
   (3) They are lined by meiotically dividing sertoli cells and germ cells
   (4) They have Leydig cells that secrete androgens
2. Ejaculatory duct is formed by uniting with a duct from which gland? [NCERT Pg. 43]
   (1) Seminal vesicle
   (2) Prostate
   (3) Vas deferens and seminal vesicle
   (4) Bulbourethral
3. Maximum number of sperms formed by 16 primary spermatocytes are [NCERT Pg. 49]
   (1) 16 (2) 32
   (3) 64 (4) 8
4. Which of the following statement is **incorrect** w.r.t. vasa deferentia? [NCERT Pg. 43]
   (1) Arises from the base of epididymis
   (2) They are two in number
   (3) They store sperms temporarily
   (4) They carry sperms from rete testis to epididymis
5. Read the following statements and select the **incorrect** option [NCERT Pg. 45]
   (1) Ovary is connected to the pelvic wall and uterus by ligaments
   (2) Fundus is thickest part of uterine tube that follows directly into of oviduct ampulla
   (3) Edges of the infundibulum possess fimbriae
   (4) Ampulla is the widest part of oviduct
6. Select the **correct** sequence of layers around ovum from outer to inner side
   (a) Zona pellucida (b) Corona radiata
   (c) Plasma membrane [NCERT Pg. 51]
   (1) a → b → c (2) b → a → c
   (3) a → c → b (4) c → a → b
7. Following is a diagrammatic sectional view of ovary. Select the **incorrectly** labelled part [NCERT Pg. 49]



   (1) Primary follicle (2) Tertiary follicle
   (3) Graafian follicle (4) Corpus luteum

NCERT Based MCQs

8. Which of the following hormone attains the highest peak in the middle of menstrual cycle with a duration of 28/29 days? [NCERT Pg. 51]
   (1) Estrogen
   (2) Progesterone
   (3) FSH
   (4) LH
9. Degeneration of which structure in ovary causes disintegration of the endometrium leading to menstruation? [NCERT Pg. 51]
   (1) Primary follicle
   (2) Secondary follicle
   (3) Graafian follicle
   (4) Corpus luteum
10. Which layer in the wall of uterus undergoes cyclical changes during menstrual cycle? [NCERT Pg. 46]
    (1) Perimetrium (2) Myometrium
    (3) Endometrium (4) Mesometrium
11. Significantly large amounts of progesterone is produced by which of the following in ovary? [NCERT Pg. 51]
    (1) Primary follicle
    (2) Mature follicle
    (3) Corpus luteum
    (4) Graafian follicle

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12. Secretions of which structures are essential for maturation and motility of sperms? [NCERT Pg. 48]

a. Epididymis
b. Vas deferens
c. Seminal vesicle
d. Bulbourethral gland

(1) a, b only
(2) b, c only
(3) a, d only
(4) a, b, c

13. How many follicles are present in each ovary at the time of puberty? [NCERT Pg. 48]

(1) 1.5-2 lakh
(2) 60,000-80,000
(3) 30,000-40,000
(4) 1,20,000-1,60,000

14. Which of the following statements are **correct** w.r.t. hymen? [NCERT Pg. 46]

(a) Is often torn during first intercourse
(b) Partially covers vaginal opening
(c) It forms a part of external genitalia

(1) a, b only
(2) b, c only
(3) a, c only
(4) a, b, c

15. How many of the following features are common for both male and female gametes in humans? [NCERT Pg. 48]

a. Presence of Locomotory structure
b. Number of chromosome
c. Arrangement of mitochondria
d. Similar size and shape

(1) a, c
(2) b, c
(3) c, d
(4) b

16. Termination of oogenesis is indicated by the formation of [NCERT Pg. 52]

(1) First polar body
(2) Secondary polar body
(3) Secondary oocyte
(4) Theca layer

17. Select the **incorrect** option with legends to oogenesis in human female? [NCERT Pg. 49]

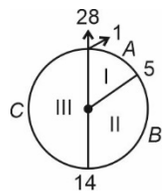
(1) Meiosis I in oogonia starts in the fetal life
(2) Tertiary follicle is characterized by presence of a distinct antrum
(3) In meiosis II, first polar body divides to form two polar bodies of equal size
(4) First meiotic division completes prior to ovulation

18. How many of the given developing stages during gametogenesis are haploid? [NCERT Pg. 49]

Spermatozoa, Secondary oocyte, Spermatid, Oogonia, Primary spermatocyte

(1) 2 (2) 3
(3) 1 (4) 4

19. Study the given diagram w.r.t menstrual cycle and select the **correct** statement regarding it [NCERT Pg. 50]



(1) A – Endometrium regenerates through proliferation
(2) B – Broken endometrium comes out through vagina.
(3) C – Graafian follicle enlarges by the end of this phase
(4) D – Secretions of endometrial glands is very high

20. Complete the analogy w.r.t. menstrual cycle

LH surge : Ovulation

Progesterone peak : _____ [NCERT Pg. 50]

(1) After ovulation (2) Before ovulation
(3) During ovulation (4) Bleeding phase

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Thinking in Context

1. In humans each testis has about _____ compartments called _____. [NCERT Pg. 43]
2. For normal fertility in humans at least _____ % of sperms must have normal shape and size. [NCERT Pg. 48]
3. Loose fold of skin around glans penis is called _____. [NCERT Pg. 44]
4. Semen contains seminal plasma secreted by male _____ glands and cells called _____. [NCERT Pg. 48]
5. Functions of male accessory ducts and glands are maintained by _____. [NCERT Pg. 48]
6. _____ number of sperms are formed from four spermatids by process known as spermiogenesis. [NCERT Pg. 49]
7. Leydig cells present in the interstitial spaces outside seminiferous tubules are also called _____. [NCERT Pg. 43]
8. Male urethra is a common passage for _____ and _____ in humans. [NCERT Pg. 43]
9. When primary follicle gets surrounded by more layers of granulosa cells and a new theca, it is called _____. [NCERT Pg. 48]
10. Zona pellucida is formed by secretions of _____. [NCERT Pg. 49]
11. _____ follicle is characterized by a fluid filled cavity, antrum. [NCERT Pg. 48]
12. About _____ million sperms are ejaculated during a coitus by a human male. [NCERT Pg. 48]
13. Two zones of ovarian stroma are outer _____ and inner _____. [NCERT Pg. 44]
14. Each ovary is approximately _____ cm in length and the oviduct is about _____ cm long. [NCERT Pg. 44,45]
15. _____ and _____ together form the birth canal. [NCERT Pg. 46]
16. Optimum temperature necessary for spermatogenesis is _____. [NCERT Pg. 43]
17. Corpus luteum exist in _____ phase of menstrual cycle. [NCERT Pg. 51]
18. Cessation of menstrual cycle is termed as _____. [NCERT Pg. 51]
19. The first menstruation begins at _____ and is called _____. [NCERT Pg. 49]
20. _____ are fleshy folds of tissue that extend from mons pubis and surrounds the vaginal opening in female external genitalia. [NCERT Pg. 46]

❑ ❑ ❑

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Human Reproduction

2B Chapter

1 INTRODUCTION

- **Sequence of reproductive events occuring in humans include:**

Gametogenesis ↓ Insemination ↓ Fertilization ↓ Implantation ↓ Gestation ↓ Parturition/Birth

2 PATH FOLLOWED BY GAMETES IN FEMALE REPRODUCTIVE TRACT

- During coitus, semen is released from male reproductive tract by the penis into the female reproductive tract *i.e.*, the vagina by process termed **Insemination**

Sperms	**Oocyte**
Released in vagina	Released in body cavity
swim through ↓	captured by ↓
Cervix	Fimbriae
enters ↓	↓
Uterus	Infundibulum
Reach	

Ampulla (site of fertilisation)

↓

Fusion of gametes/**syngamy**/**Fertilization** (vital event of sexual reproduction)

- Fertilization can only occur if the **ovum** and **sperms** are **transported simultaneously** to the ampullary region. This is the reason why not all copulations leads to fertilization and pregnancy

3 CHANGES IN GAMETES DURING FERTILIZATION

Secretions of **Acrosome part of sperm** ↓ allow

Entry of sperm into cytoplasm of oocyte through zona pellucida and plasma membrane

- Changes in zona pellucida prevent entry of additional sperms and **ensures that only one sperm can fertilise an ovum**

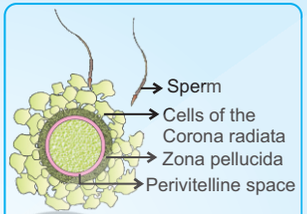


Fig. : Ovum surrounded by few sperms

Inducing completion of Meiosis II of secondary oocyte

Form
- *Cytoplasmically unequal 2nd meiotic division*

2nd Polar body **(n)** (1) — (*Released in Perivitelline space*)

Ovum/ootid **(n)** (1) + Sperm **(n)** → Nuclei fuse → **Zygote** (2n)

- **Characteristics :**
  - Vital link that ensures continuity of species between organism of one generation and the next.
  - Sex of a child is decided at this stage

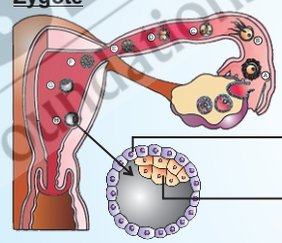
4 SEX OF A BABY IS DETERMINED BY THE FATHER

Parameters	**Female**	**Male**
Chromosome pattern	XX	XY
Gametes formed	X X	X Y
Fusion of gametes	XX XX (**Female**)	XY XY (**Male**)

- 50% male gametes carry X chromosome and 50% carry Y chromosome
- Zygote would carry either XX or XY depending on whether the sperm carrying X or Y fertilizes the ovum

5 DEVELOPMENT OF THE ZYGOTE

- Every sexually reproducing organism, including human beings begin life as a single cell *i.e.*, the **zygote**.
- The process of development of embryo from zygote is called **embryogenesis**.
- During embryogenesis, zygote undergo **cell divisions** and **cell differentiation**
- Cleavage starts as zygote moves through isthmus to the uterus
- Daughters formed after cleavage are called **Blastomeres**



Trophoblast – Outer layer of blastomeres attaches to endometrium

Inner cell mass – Inner group of cells attached to trophoblast → Differentiates into embryo with three germ layers

Blastocyst
Implants in uterus

The inner cell mass contains certain cells called **stem cells** which have the potency to give rise to all the tissues and organs.

After attachment, uterine cells divide rapidly and cover the blastocyst.
Embedding of blastocyst in endometrium is called **Implantation**
Leads to ↓ **Pregnancy**

- **Germ layers**
  - Outer – Ectoderm
  - Middle – Mesoderm
  - Inner – Endoderm

} These together give rise to all tissues/organ in adults.

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6 CHANGES AFTER IMPLANTATION

Embryo/Foetus — Finger like projections appear on the trophoblast called **chorionic villi**

Mother — Uterine tissue

↓ Interdigitate to form

Placenta (Structural and functional unit between embryo/foetus and mother)

- **Functions:**
  - Supply of O_2 and nutrients to the embryo
  - Removal of CO_2 and excretory/waste materials produced by the embryo
  - **Acts as endocrine tissue :**
    - hCG/human chorionic gonadotropin
    - hPL/human placental lactogen

    } Produced only during pregnancy
    - Relaxin (Also secreted by ovary in later phase of pregnancy)
    - Estrogens
    - Progestogens
    - Cortisol
    - Prolactin
    - Thyroxine

    } **Increase several folds during pregnancy, essential for supporting:**
      - Foetal growth
      - Metabolic changes in mother
      - Maintenance of pregnancy

- Placenta is connected to the embryo through an **umbilical cord** which helps in the transport of substances to and from the embryo

7 GESTATION PERIOD

- Average duration of pregnancy in
  - Dog ~ 63 days
  - Cat ~ 63 days
  - Elephant ~ 18-22 months
  - Human ~ 9 months

Major events during gestation period in humans:

Trimester	Month	Week	Event
1st	I	4	Heart is formed, sign of growing foetus noticed by listening to the heart sounds through stethoscope
	II	8	Foetus develops limbs and digits
	III (end)	12	Most of major organ systems are formed including external genital organs
2nd	V	20	First movement of foetus, Appearance of hair on head
	VI (end)	24	Body is covered with fine hair, Eyelids separate, Eyelashes are formed
3rd	IX (end)	36	Foetus is fully developed and is ready for delivery

8 PARTURITION

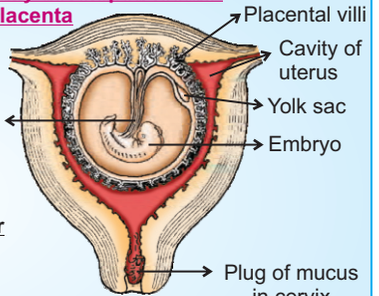
- **Defined as delivery of the foetus (Child birth)**
- **Signals for parturition originate from** → **Fully developed foetus** and **Placenta**

Lead to ↓ Mild uterine contractions called ↓ **Foetal ejection reflex** triggers ↓ release of **Oxytocin from posterior pituitary of mother**

This is positive feedback loop

Causes ↓ Strong uterine contractions leading to ↓ Expulsion of baby through birth canal **(Parturition)** followed by ↓ Expulsion of placenta

*Oxytocin is synthesized by its **source gland hypothalamus** but released from posterior pituitary.



The human foetus within the uterus

- Child birth is induced by a complex **neuroendocrine mechanism** involving **cortisol, estrogens and oxytocin**.
- **Doctors inject oxytocin to induce delivery.**

9 MAMMARY GLANDS AND LACTATION

- Functional mammary gland is characteristic of all female mammals
- Paired structures (Breasts) that contain variable amount of fat and **Glandular tissue**

divided into ↓ (15-20) **Mammary lobes** contain ↓ **Mammary alveolus**/ cluster of cells (*secrete and store milk*) in their lumen opens into ↓ **Mammary tubules** join to form ↓ **Mammary duct** Many join to form ↓ **Mammary ampulla** connected to ↓ **Lactiferous duct** (Through which milk is sucked out)

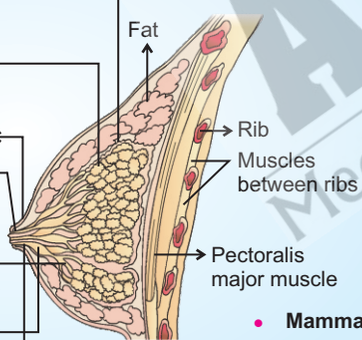


Fig.: Sectional view of Mammary gland

- **Mammary glands** → Undergo differentiation during pregnancy; Secrete milk after child birth that helps mother in feeding new born by process called **lactation**.
- Milk produced during initial few days of lactation is called **colostrum** which contains several antibodies, absolutely essential to develop resistance for the new born babies.
- Breast feeding during the initial period of infant growth is recommended by doctors for bringing up a healthy baby

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Sharpen Your Understanding

1. Read the following statements and select the **correct** option

Statement A : All copulations do not lead to fertilization and pregnancy.

Statement B : Fertilization is possible only if ovum and sperms are transported simultaneously to the ampullary region. [NCERT Pg. 51]

(1) A is true and B is incorrect statement
(2) Both A and B statements are correct
(3) Only B statement is correct
(4) Both A and B are incorrect

2. Which of the following event triggers the formation of ootid? [NCERT Pg. 52]

(1) Entry of sperm in fallopian tube
(2) Binding of sperm to zona pellucida
(3) Changes in the plasma membrane of sperm
(4) Entry of sperm into cytoplasm of secondary oocyte

3. Which region of blastocyst contains stem cells that have potency to give rise to all the tissues and organs? [NCERT Pg. 54]

(1) Trophoblast
(2) Blastocoel
(3) Inner cell mass
(4) Zona pellucida

NCERT Based MCQs

4. In mammals, embryo proper is formed from [NCERT Pg. 53]

(1) Trophoblast
(2) Inner cell mass
(3) Chorionic villi
(4) Polar body

5. Implantation usually occurs at [NCERT Pg. 53]

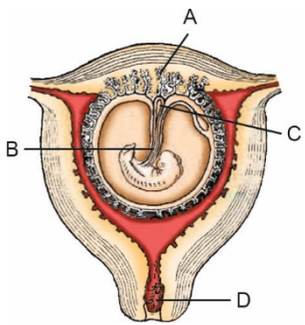
(1) Morula stage
(2) Zygote stage
(3) Blastocyst stage
(4) First cleavage stage

6. During pregnancy hormones like thyroxine, estrogen, progesterone *etc.*, increase several folds in the maternal blood. Which of the following features justify this increase? [NCERT Pg. 53]

a. Support fetal growth
b. Support metabolic changes in the mother
c. Essential for maintenance of pregnancy
d. To promote menstrual cycle on regular basis during pregnancy

(1) a, b only
(2) b, c only
(3) a, d only
(4) a, b, c

7. In the figure shown below, which labelled structure has **not** been correctly identified? [NCERT Pg. 53]



(1) A-Placental villi (2) B-umbilical cord
(3) C-Yolk sac (4) D-Cervical plug

8. Foetal ejection reflex in human female is induced by [NCERT Pg. 54]

(1) Release of oxytocin from fetal pituitary
(2) Signals from fully developed foetus and placenta
(3) Release of oxytocin from adenohypophysis
(4) Pressure exerted by water bag on uterine wall

9. Which of the following hormone, do the doctors inject to induce delivery? [NCERT Pg. 54]

(1) Estrogen (2) Progesterone
(3) Prolactin (4) Oxytocin

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10. Breast feeding during initial period of infant growth is recommended by doctors for bringing up a healthy baby because it contains [NCERT Pg. 54]

(1) High amount of iron

(2) Low amount of cholesterol

(3) Almost all vitamins

(4) Several antibodies

11. Milk is secreted by the alveoli present in the mammary lobes and it reach upto nipple through following regions. Arrange these regions in a **correct** order [NCERT Pg. 46]

a. Lactiferous duct b. Mammary duct

c. Ampulla d. Mammary tubule

(1) b $\rightarrow$ c $\rightarrow$ d $\rightarrow$ a (2) d $\rightarrow$ b $\rightarrow$ c $\rightarrow$ a

(3) b $\rightarrow$ d $\rightarrow$ c $\rightarrow$ a (4) a $\rightarrow$ b $\rightarrow$ d $\rightarrow$ c

12. Which regions of glandular tissue in mammary glands store milk? [NCERT Pg. 47]

(1) Mammary tubule (2) Mammary alveoli

(3) Lactiferous duct (4) Mammary duct

13. Parturition is the process of giving birth to a baby. It is controlled by [NCERT Pg. 54]

(1) Neural mechanism only

(2) Endocrine mechanism only

(3) Physical mechanism only

(4) Neuro-endocrine mechanism

14. Foetal movement starts usually from [NCERT Pg. 54]

(1) II month of pregnancy

(2) III month of pregnancy

(3) IV month of pregnancy

(4) V month of pregnancy

15. Which of the following event takes place earliest by the end of first month of embryonic development? [NCERT Pg. 54]

(1) Major organs are formed

(2) Foetus develops limbs and digits

(3) Embryo's heart is formed

(4) Movement of foetus is observed

16. Select the **correct** option w.r.t. given statements [NCERT Pg. 53]

Statement A: After implantation, blastocyst gets embedded in the endometrium of uterus

Statement B: Uterine cells divide rapidly and cover the blastocyst once it gets attached to the uterine wall

(1) Both A and B statements are correct

(2) Only B is the correct statement

(3) Both A and B statements are incorrect

(4) A is correct and B is an incorrect statement

17. Which of the following hormone is secreted by placenta only? [NCERT Pg. 53]

(1) Oxytocin

(2) Estrogen

(3) Progesterone

(4) hCG

18. In humans, the placental villi are derived from [NCERT Pg. 53]

(1) Yolk sac (2) Chorion

(3) Endometrium (4) Water bag

19. Foetal ejection reflex triggers the release of [NCERT Pg. 54]

(1) Oxytocin from foetal pituitary

(2) Oxytocin from placenta

(3) Oxytocin from maternal pituitary

(4) hPL from placenta

20. Which of the following event is the last one to be observed during gestation period in a normal pregnancy? [NCERT Pg. 54]

(1) Eyelids separate and eyelashes are formed

(2) Listening to the heart sound of foetus through stethoscope

(3) Secretion of oxytocin from mammary glands

(4) Vigorous contractions of uterus

Thinking in Context

1. The process of fusion of a sperm with an ovum is called _____. [NCERT Pg. 51]
2. After implantation, finger like projections appear on the trophoblast called _____. [NCERT Pg. 53]
3. First cell of a new generation is termed _____. [NCERT Pg. 52]
4. Secretions of _____ help the sperm entry into the cytoplasm of ovum through zona pellucida. [NCERT Pg. 51]
5. Morula is _____ blastomere stage in humans. [NCERT Pg. 53]
6. Early repeated mitotic divisions in the zygote are called _____. [NCERT Pg. 52]
7. All the three germ layers of embryo are formed from _____. [NCERT Pg. 54]
8. In humans during coitus, male ejaculates about _____ sperms in the vagina of females. [NCERT Pg. 48]
9. In foetus, most of the major organ systems are formed by the end of _____. [NCERT Pg. 54]
10. Gestation period in humans averages around _____. [NCERT Pg. 54]
11. _____ and _____ hormones have lactogenic properties. [NCERT Pg. 53]
12. _____ and _____ hormones are produced by both placenta as well as ovary. [NCERT Pg. 53]
13. Sex of a baby is decided at the time of _____ formation. [NCERT Pg. 52]
14. Oxytocin acts on uterine muscles and causes stronger contractions, which in turn stimulates further secretion of _____ hormone. [NCERT Pg. 54]
15. The process of child birth is called _____. [NCERT Pg. 54]
16. The milk produced in early few days after delivery is called _____. [NCERT Pg. 54]
17. Placenta is connected to the embryo through _____. [NCERT Pg. 53]
18. Structural and functional unit formed between developing foetus and maternal body is called _____. [NCERT Pg. 53]
19. Number of lobes found in each mammary gland of human female are _____. [NCERT Pg. 47]
20. Out of the three germ layers, X is formed after formation of Y and Z layers. [NCERT Pg. 54]

❑ ❑ ❑

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Reproductive Health

3 Chapter

1 INTRODUCTION

- **Definition**

  According to WHO, reproductive health means a total well being in all aspects of reproduction *i.e.* physical, emotional, social and behavioral.

3 POPULATION STABILISATION

- According to 2011 census, our population growth rate was **less than 2 percent *i.e* 20/1000/year**

Year	World Population	Indian Population
1900	2 billion	350 million
2000	6 billion	1 billion
2011	7.2 billion	1.2 billion

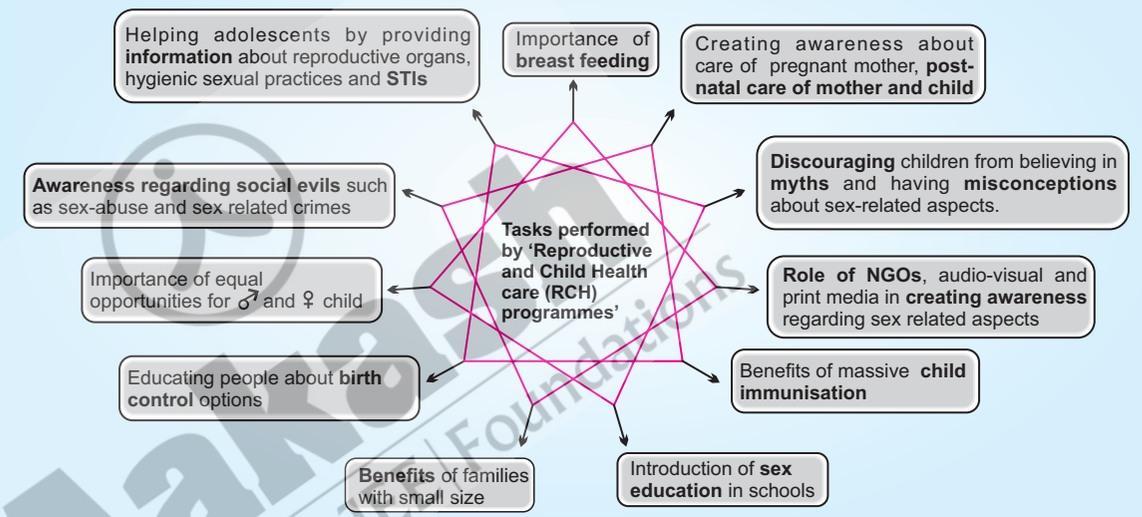
- **Reasons For Increase In Population Size:**
  - Decline in death rate
  - Rapid decline in maternal mortality rate (MMR)
  - Decrease in infant mortality rate (IMR)
  - Increase in number of people in reproducible age
  - Increase in health facilities
- **Measures Taken By Government To Check Population Growth Rate:**
  - Motivate smaller families by using various contraceptive methods with slogans"**Hum do Hamare do**", advertisements and posters
  - Urban couples adopting : **"One child norm"**
  - Statutory raising of marriageable age:
    - Female to 18 years
    - Male to 21 years
  - Incentives given to couples with small families

4 BIRTH CONTROL/CONTRACEPTION

- **Features of an ideal contraceptive**:
  - User-friendly
  - Easily available
  - Effective
  - Reversible
  - No/least side-effects
  - No interference with libido or act of coitus
- **There are two principle methods of birth control:**
  - Natural methods
  - Artificial methods

2 REPRODUCTIVE HEALTH : PROBLEMS AND STRATEGIES

- India was amongst first countries in the world to initiate action plans to attain reproductive health such as **family planning programmes (FPP) in 1951**


Helping adolescents by providing **information** about reproductive organs, hygienic sexual practices and **STIs**
Importance of **breast feeding**
Creating awareness about care of pregnant mother, **post-natal care of mother and child**
Awareness regarding social evils such as sex-abuse and sex related crimes
Discouraging children from believing in **myths** and having **misconceptions** about sex-related aspects.
Tasks performed by 'Reproductive and Child Health care (RCH) programmes'
Importance of equal opportunities for ♂ and ♀ child
Role of NGOs, audio-visual and print media in **creating awareness** regarding sex related aspects
Educating people about **birth control** options
Benefits of massive **child immunisation**
Benefits of families with small size
Introduction of **sex education** in schools

5 NATURAL/TRADITIONAL METHODS

- Principle of avoiding physical meeting of the egg and sperms
- Chances of failure are high

Method	Mode of Action (MoA)
Periodic abstinence	: Couples abstain from coitus from day 10 to 17 of the menstrual cycle *i.e.* fertile period
Withdrawal method/ Coitus interruptus	: Insemination is avoided as the male partner withdraws his penis from the vagina just prior to ejaculation
Lactational amenorrhea	: Absense of menstruation upto 6 months during period of intense lactation following parturition

6 ARTIFICIAL METHODS

The various methods of contraception are enlisted below:

I. Barrier methods
II. Spermicidal jellies
III. IUDs
IV. Oral pills
V. Injections and implants
VI. Emergency contraceptives
VII. Surgical methods

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7 ARTIFICIAL METHODS

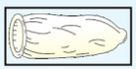
(I). Barrier methods

- Prevent ovum and sperm from physically meeting
- Self inserted and offer privacy to user

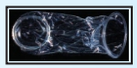
(a) Condoms & its types

Made up of rubber and thin latex

Parameter	Males	Females
• Region covered	• Penis	• Vagina and cervix
• Provides protection from STIs	• Yes	• Yes



Male condom (Nirodh)



Female condom

(b) Diaphragms, cervical caps, vaults

- Rubber barriers that **cover** the **cervix** during coitus
- Reusable
- **Do not protect from STIs**
- Used by females only

(II). Spermicidal jellies, foams and creams

- Kill the sperms by creating acidic pH
- Used along with barrier methods to increase their efficiency

(III). Intra-uterine devices (IUDs)

- Inserted by doctors or expert nurses in uterus
- IUDs are one of the most widely accepted method of contraception in India.

Types

- **Non medicated IUDs**
- **Example:** "Lippe's loop"
- **Medicated IUDs**

Parameter	Hormone releasing IUDs	Copper coated IUDs
• Examples	Progestasert, LNG-20	Cu7, Multiload 375
• Mode of Action	◆ Make the uterus unsuitable for implantation and cervix hostile to the sperms.	◆ Increase phagocytosis of sperms within uterus ◆ Cu ions suppress sperm motility and fertilising capacity of sperms

CuT

IV. Oral Contraceptive Pills (OCP) or tablets

Parameter	Non-steroidal	Steroidal
• Example or composition	SAHELI	Progestogens (Prg) alone or combination of Prg and Estrogens (Est)
• Mode of action	Interferes with implantation	Inhibit ovulation and implantation; also alter the quality of cervical mucus to retard entry of sperms
• Dosage	'Once a week' pill	Pills have to be taken daily for a period of 21 days starting preferably within first 5 days of menstrual cycle
• Effectiveness	High contraceptive value with very few side effects	Pills are very effective with lesser side effects and well accepted by females

Saheli was developed at CDRI, Lucknow, Uttar Pradesh

V. Implants

- Placed under skin
- Effective periods are much longer
- **Composition:** Progestogens alone/Combination of Progestogens and Estrogens
- **Mode of Action (MoA)**
  - ◆ Inhibit ovulation and implantation
  - ◆ Alter the quality of cervical mucus to retard entry of sperms
- Injections usually share similar MoA and composition as implants

VI. Emergency contraceptives

Types	Characteristics
• Progestogens alone • Combination of Prg + Est • IUDs	• Effective with 72 hrs of coitus • Used to prevent conception resulting from rape or unprotected intercourse

VII. Surgical/Sterilisation methods

- Poor reversibility but highly effective
- **Mode of action**

Blocks gamete transport

Types

Tubectomy	Vasectomy
• In females	• In males
• Cut and tie **fallopian tubes**	• Cut and tie **vas deferens**
• Incision in abdomen or through vagina	• Small incision on the scrotum

8 MEDICAL TERMINATION OF PREGNANCY(MTP)/INDUCED ABORTION

- **MTP** : Intentional or voluntary termination of pregnancy before full term
- MTP was legalised in India in **1971**
- **When can MTP be performed?**
  - Unwanted pregnancy due to rape, failure of contraception, casual unprotected intercourse
  - If continuation of pregnancy could harm the mother or foetus or both
  - **Permission of how many medical practitioners is needed for MTP depending on duration of gestation?**

1	2
less than/upto 12 weeks	More than 12 but less than 24 weeks

- **Intention behind MTP amendment act 2017, (GoI)**
  - Reducing the incidence of illegal abortion
  - Decrease consequent maternal mortality and morbidity
  - MTPs are **safe** upto 12 weeks but riskier in 2nd trimester yet both are **legal**
  - Amniocentesis and MTPs have been misused in context of **female foeticide**

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9 AMNIOCENTESIS

- Analyse foetal cells and dissolved substances from amniotic fluids
- Technique used to check for genetic disorders such as Down's syndrome, hemophilia, sickle-cell anemia *etc.*
- **Statutory ban on this technique in India to prevent female foeticide.**

10 SEXUALLY TRANSMITTED INFECTIONS (STIs)

- **Alternately named:** Venereal diseases (VD) or reproductive tract infections (RTIs)
- **High vulnerability/risk group:** 15-24 years
- **Mode of transmission (MoT):** Sexual intercouse

Category	Disease
Bacterial	Gonorrhea, Syphilis, Chlamydiasis
Protozoan	Trichomoniasis
Viral	Genital herpes, Hepatitis-B, Genital warts, AIDS

- Bacterial and protozoan diseases are completely curable if detected early and treated properly
- **Other MoT for hepatitis-B virus and HIV infection include:**
  - Sharing of injection needles, surgical instruments with infected persons
  - Transfusion of blood
  - From infected mother to foetus

11 INFERTILITY

- **Infertile couple:** Unable to produce children inspite of 2 years of unprotected sexual co-habitation
- **Reasons for infertility:**
  - Physical
  - Diseases
  - Psychological
  - Congenital
  - Immunological
- Infertility as a problem could be with either the male or female partner.
- In India, female is blamed often than male for the couple being childless

Help For Infertile Couples Comes In The Form of ASSISTED REPRODUCTIVE TECHNOLOGIES (ART)

Parameter	*in-vitro* fertilisation	*in-vivo* fertilisation
Site of fertilisation	Outside the body in simulated conditions in laboratory	In the female reproductive tract
Can female produce ova?	Yes	No
Embryo transfer	Yes	No
Example of techniques	ZIFT, IUT, ICSI	GIFT, AI, IUI

- **Other details of ART involved :**
  - **ICSI :** Intra cytoplasmic sperm injection
    - Sperm injected directly into the egg
  - **Artificial Insemination (AI):**
    - Semen introduced in vagina or uterus
    - Low sperm count or inability of male to inseminate female
    - **IUI :** Intra uterine insemination
  - **GIFT :** Gamete intra fallopian transfer
    - Female can provide conditions for fertilisation and further development

Site of Embryo Transfer (ET) based on number of blastomeres

Parameter	Upto 8 blastomeres	More than 8 blastomeres
Location	in fallopian tube	in uterus
Technique	ZIFT: Zygote Intra fallopian transfer	IUT: Intra uterine transfer

Test tube baby programme involves techiques with ***in-vitro* fertilisation**

- **Symptoms and Complications of STIs**

Early detection (Symptoms)	Late detection (Complications)
Itching, fluid discharge, slight pain, swellings in the genital region	Pelvic inflammatory diseases (PIDs), abortions, still births, ectopic pregnancies, infertility, cancer of reproductive tract

- **Preventive measures to avoid STIs :**
  - Avoid sex with unknown partners/multiple partners
  - Always try to use condoms during coitus

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Sharpen Your Understanding

NCERT Based MCQs

1. "Reproductive health means total well being in all aspects of reproduction *i.e*, physical, behavioural and social". Which agency/organisation is responsible for ratifying this on global scale? [NCERT Pg. 57]

(1) NDRI (2) CDRI

(3) WHO (4) IARI

2. In which year were the 'family planning programmes' initiated in our country? [NCERT Pg. 57]

(1) 1981 (2) 1961

(3) 1983 (4) 1951

3. Among following, detection of which defect is **not** possible using the technique amniocentesis? [NCERT Pg. 58]

(1) Down's syndrome

(2) Cleft palate

(3) Neural tube defects

(4) Klinefelter's abnormality

4. Read the given statements

I. Amniocentesis is a foetal sex determination test based on study of chromosomal pattern from cells extracted from amniotic fluid

II. There is a statutory ban on this technique w.r.t. sex determination in India

Choose the **correct** option [NCERT Pg. 58]

(1) Only statement I is true

(2) Only statement II is true

(3) Both statement I and II are wrong

(4) Both statement I and II are true

5. Saheli, a new contraceptive drug was developed at CDRI. This research institute is located in [NCERT Pg. 58]

(1) Andhra Pradesh

(2) Madhya Pradesh

(3) Uttar Pradesh

(4) Arunachal Pradesh

6. Which method is used by females that works on the principle of avoiding chances of ovum and sperm meeting and involves use of latex sheath? [NCERT Pg. 60]

(1) Lactational amenorrhea

(2) Copper-T

(3) Periodic abstinence

(4) Femidoms

7. Select the **odd one** w.r.t. reusability [NCERT Pg. 60]

(1) Diaphragms

(2) Nirodh

(3) Vaults

(4) Cervical caps

8. Mode of action of oral pills in contraceptive context does **not** include their ability to [NCERT Pg. 61]

(1) Promote sperm motility and enhance fertilization ability

(2) Alter quality of cervical mucus

(3) Inhibit ovulation

(4) Impair implantation

9. Which of the following is a copper based IUD that can last for longest time amongst them? [NCERT Pg. 60]

(1) Multiload 375 (2) Cu 7

(3) LNG-20 (4) CuT

10. Surgical intervention technique that blocks gamete transport in females is called [NCERT Pg. 61]

(1) Hysterectomy (2) Tubectomy

(3) Vasectomy (4) Mastectomy

11. Induced abortion [NCERT Pg. 62]

(1) Refers to intentional or voluntary termination of pregnancy before full term

(2) Has a significant role in decreasing the population as it is aimed at lowering population growth

(3) Was legalized in India in 2001

(4) Considered illegal if performed for female foetus in first trimester under medical supervision

12. Choose the option that completes the analogy correctly amongst given STIs.

Gonorrhea : Bacterial : : Trichomoniasis : _____ [NCERT Pg. 63]

(1) Viral

(2) Bacterial

(3) Fungal

(4) Protozoan

13. How many among following can be transmitted by sharing of needles? [NCERT Pg. 63]

Syphilis, Genital herpes, chlamydiasis, hepatitis-B, genital warts, HIV

(1) One

(2) Three

(3) Two

(4) Five

14. In which of the following techniques does fusion of gametes occurs inside female's reproductive tract? [NCERT Pg. 64]

(1) GIFT (2) ZIFT

(3) ICSI (4) IUT

15. *In-vitro* fertilization to help overcome infertility is possible in case of [NCERT Pg. 64]

(1) GIFT (2) IUI

(3) AI (4) ICSI

16. Select the **incorrect** match [NCERT Pg. 60]

	Column-A		Column-B
(1)	Coitus interruptus	–	Natural method of conception
(2)	Lactational amenorrhea	–	Absence of menstruation
(3)	Condoms	–	Protect the user from STIs
(4)	Spermicidal jellies	–	Increase contraceptive efficiency of barrier methods

17. Read the given statements [NCERT Pg. 66]

a. All sexually transmitted infections are completely curable

b. Sterilisation methods of contraception reduce gametogenesis.

c. Increase in IMR could attribute to increase is population size in India in the last decade

Select the **correct** option

	a	b	c
(1)	T	T	T
(2)	F	F	F
(3)	T	F	T
(4)	F	T	F

18. Select the **incorrect** statement [NCERT Pg. 64]

(1) Abortions can happen spontaneously too

(2) Infertility is defined as the ability to produce an inviable offspring and is always due to defects in male partner

(3) Creating awareness about sex related aspects is an effective method to improve reproductive health of the people

(4) Continued intense lactation could help as a natural method of contraception upto maximum six months from parturition

19. Choose the **odd** one w.r.t. contraceptive methods [NCERT Pg. 59]

(1) MTP (2) Withdrawal method

(3) Implants (4) IUDs

20. Medical termination of pregnancy can be performed in all given cases **except** [NCERT Pg. 62]

(1) Pregnancy can be fatal to foetus and mother as she met with an accident

(2) Unwanted pregnancy resulting from rape

(3) Conception due to failure of the contraceptive

(4) Pregnancy has reached middle of third trimester

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Thinking in Context

1. Couples are termed infertile when they are unable to produce children inspite of_____ sexual co-habitation. [NCERT Pg. 63]
2. Government of India legalized MTP in _____ with some strict conditions to avoid its mis-use. [NCERT Pg. 62]
3. Human immunodeficiency virus can be transmitted by sharing surgical instruments with infected persons,_____ of blood, or from infected mother to foetus. [NCERT Pg. 63]
4. Persons belonging to age group_____ years are highly vulnerable to STIs. [NCERT Pg. 63]
5. If pregnancy has crossed 12 week stage but is still in second trimester, MTP can be performed with consent of _____ medical practitioners. [NCERT Pg. 62]
6. The world population which was around_____ million in 1900 rocketed to about_____ billion by 2000. [NCERT Pg. 59]
7. A rapid decline in death rate, _____ and _____ as well as increase in number of people in reproducible age group are probable reason for increase in population size in India . [NCERT Pg. 59]
8. To promote small family size, Indian government has raised the statutory marriage age of the females to _____ years and that of males to_____ years. [NCERT Pg. 59]
9. During periodic abstinence, a couple refrains from coitus from day _____ of the menstrual cycle when ovulation could be expected in a female with 28 day cycle. [NCERT Pg. 59]
10. An ideal contraceptive should be user friendly, _____ available, effective and reversible. [NCERT Pg. 59]
11. _____ is a method in which the male partner withdraws his penis from the vagina just prior to ejaculation. [NCERT Pg. 60]
12. Chances of conception are relatively _____ when exercising natural methods of contraception as compared to use to implants. [NCERT Pg. 61]
13. Diaphragms and vaults act by preventing/blocking the entry of sperms through _____ in a female. [NCERT Pg. 60]
14. _____ IUD makes the uterus unsuitable for implantation and the cervix hostile to the sperms. [NCERT Pg. 60]
15. Pills have to be taken daily for a period of ____ days starting preferably within first five days of menstrual cycle. [NCERT Pg. 61]
16. Administration of progestogens or IUDs within _____ hours coitus are effective contraceptives. [NCERT Pg. 61]
17. In tubectomy, small part of the fallopian tube is removed or tied up through a small incision in the _____ or through____. [NCERT Pg. 62]
18. Early symptoms of sexually transmitted infections include ____, fluid discharge, slight pain and swelling in genital region. [NCERT Pg. 63]
19. GIFT is used by females who cannot produce an ova but can provide suitable environment for ____ and further foetal development. [NCERT Pg. 64]
20. In artificial insemination, the semen collected from either_____ or _____ is artificially introduced into the vagina or into the uterus. [NCERT Pg. 64]

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Evolution

4 Chapter

1 EVOLUTION

- **Evolutionary biology** is the study of history of life forms on earth
- Stellar distances are measured in light years
- **Big bang explosion** (Singular huge explosion)

↓ Resulted in

Parameters	Origin of Universe	leading to → Origin of Earth
Time scale	• 20 billion years ago	• 4.5 billion years ago
Feature	• Comprises cluster of galaxies (stars, clouds of gas, dust)	• Occurred in solar system of **Milkyway galaxy**

Events after expansion of universe:

- Temperature declined
- H_2 + He formed
- Gases condensed
- Galaxies of present day formed

Hypothesis for Origin of life on early earth:

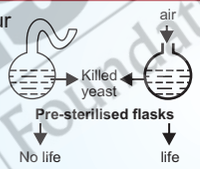
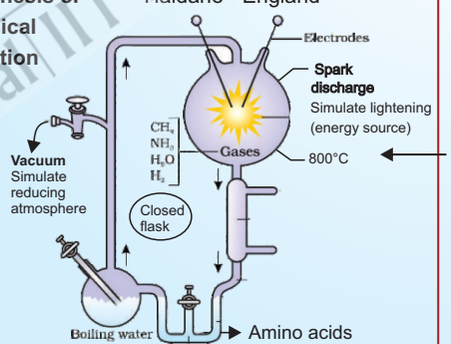
- No atmosphere existed on early earth.
- Water vapours, methane, carbon dioxide and ammonia released from molten mass covered the surface.
- $H_2O \xrightarrow{\text{U.V rays}} H_2 + O_2$
- $\left.\begin{matrix} NH_3 \\ CH_4 \end{matrix}\right] + O_2 \longrightarrow CO_2 + H_2O$ + other contents
- H_2O vapour falls as rain to fill all the depressions and form oceans.
- Ozone layer was formed

2 ORIGIN OF LIFE

- **Life appeared** 500 million years after the formation of earth, i.e, almost **4 billion years ago**.
- **First non-cellular forms of life**
  - **Probably originated 3 billion years ago**
  - Would have possibly originated from giant molecules (RNA, protein, polysaccharides, etc.)
  - These capsules **reproduced** their molecules perhaps.
- **First cellular forms of life**
  - **Possibly originated 2 million years ago**
  - Arose in water environment (aquatic)
- **This version of Biogenesis i.e., the first form of life arose slowly through evolutionary forces from non-living molecules is accepted by majority.**

3 THEORIES FOR ORIGIN OF LIFE

- The origin of life is considered a unique event in the history of universe

Theory	Proponents	Connotations
Special creation	Conventional religious literature	• All living organisms that we see today were created as such • Diversity was always the same since creation and will be the same in future also • Earth is 4000 years old
Cosmozoic/ Panspermia	Early Greek thinkers, Astronomers	• Life came from outerspace • **Units of life called spores** were transferred to different planets including earth
Spontaneous generation	–	• Life came out from decaying and rotting matter like straw, mud. etc. • **Disapproved by Louis Pasteur**
Theory of Biogenesis	Louis Pasteur 	• **Life comes only from pre-existing life** • He showed that in pre-sterlised flasks, life did not come from "**killed yeast**"
Oparin-Haldane hypothesis or Chemical Evolution	Oparin - Russia, Haldane - England  Fig.: Diagrammatic representation of Miller's experiment	• Formation of life was preceded by chemical evolution *i.e.*, formation of diverse organic molecules from inorganic constituents. • First form of life could have come from pre-existing non-living organic molecules (e.g. RNA, proteins, etc.) • This hypothesis was proved by Miller's experiment, **1953, S.L. Miller (American scientist)** • In similar experiments others observed, formation of sugars, nitrogen bases, pigments and fats. • **Analysis of meteorite content also revealed similar compounds indicating that similar processes are occuring elsewhere in space**.

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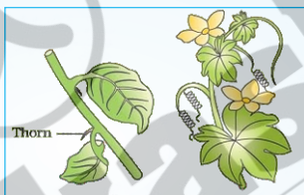
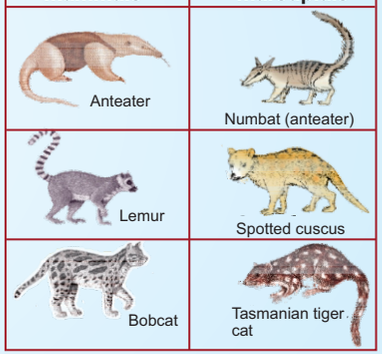
4 EVIDENCES OF EVOLUTION

1. **Palaeontological evidences** (Evidences from fossils)
   - **Fossils** are remains of hard parts of life forms found in rocks.
   - **Age of fossils** is determined by **radioactive-dating method**.
   - Fossils of different life forms in different **sedimentary layers** indicates the **geological period** in which they existed (**epochs, periods, eras**)
   - Rocks form sediments and a cross-section of earth's crust indicates the arrangement of sediments one over the other during the long history of earth.
   - Different-aged rock sediments contain fossils of different life-forms who probably died during the formation of the particular sediment. Some of them appear similar to modern organisms. **They represent extinct organisms (e.g., Dinosaurs)**.
2. **Embryological evidences**
   - Proposed by **Ernst Heckel**
   - Based upon the observations of certain features during embryonic stage common to all vertebrates that are absent in adults *e.g.*, embryos of all vertebrates develop a row of vestigial gill slits functional only fish and not found in another adult vertebrates.
   - It was **disproved by Karl Ernst von Baer**. He noted that embryos never pass through the adult stages of other animals.

3. **Morphological and anatomical evidences**

Parameters	Homologous organs	Analogous organs
Common ancestory	✓	✗
Anatomical structures	Similar but developed along different directions due to adaptations to different needs.	Not similar but resulted in selection of similar adaptive features in different groups of organisms, thus, evolving for the same function.
Function performed	Different	Similar
Type of evolution	Divergent	Convergent
Examples	• **Thorn of *Bougainvillea* and tendril of *Cucurbita***  • **Forelimbs of vertebrates** • Vertebrate hearts, Vertebrate brains	• **Placental mammals** / **Australian marsupials**  • Wings of butterfly and birds • Eyes of octopus and mammals • Flippers of Penguins and Dolphins • Sweet potato (root modification) and potato (stem modification)

- **Molecular homology**
  Similarities in proteins and genes performing a given function among diverse organisms indicates **common ancestry.** These **biochemical similarities** point to the same **shared ancestry** as structural similarities among diverse organisms.

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5 ADAPTIVE RADIATION

- The process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats)

Examples

Darwin's finches

- Small black birds
- Evolved from **seed eating** birds in **Galapagos Island**
- Altered beaks arose, enabling them to become insectivorous and vegetarian finches.

Fig.: Variety of beaks of finches that Darwin found in Galapagos Island

Australian marsupials

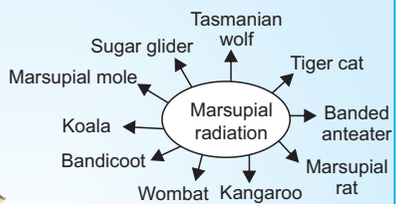

Fig.: Adaptive radiation of marsupials of Australia

- When more than one adaptive radiation appeared to have occurred in an isolated geographical area (representing different habitats), one can call this **convergent evolution**.

Examples	
Placental mammals	**Australian marsupials**
Mole	Marsupial mole
Anteater	Numbat (banded anteater)
Mouse	Marsupial mouse
Lemur	Spotted cuscus
Flying squirrel	Flying phalanger (Sugar glider)
Bobcat	Tasmanian tiger cat
Wolf	Tasmanian wolf

6 BIOLOGICAL EVOLUTION

- **Metabolic capabilities of different cellular forms** of life under the influence of natural selection **contributed to biological evolution**.
- **Rate of appearance of new forms is linked to the life cycle or the life span**. e.g., Microbes have the ability to multiply and become millions within hours whereas fish or fowl would take millions of years as life span of these animals are in years.

Theories for the evolution of life forms:

Lamarck's theory of evolution

- Given by French naturalist Lamarck
- **Main postulates :** Use and disuse of organs; Inheritance of acquired characters
- **Example:** Long neck in Giraffes is attributed to stretching the neck while foraging leaves on tall trees

Darwin's theory of natural selection

- Darwin visited Galapagos island, **Ship - H.M.S Beagle**
- **Observations by Charles Darwin:**
  - (i) Existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago.
  - (ii) The **geological history of earth** correlates with the **biological history of earth**.
- Influence of the work of **Thomas Malthus** on Darwinism:
  - (i) Population can grow exponentially
  - (ii) Limited resources
  - (iii) Nature keeps control/check on population size which are, hence, nearly stable

Darwin's postulates:

- According to Darwin, variations are **small** and **directional** and evolution for Darwin was **gradual** process.
- Darwin asserted that in a population exist **variations,** which are **heritable** and which make **resource utilisation** better for few will enable only those to **reproduce** and leave **more progeny**.
- Those characteristics which enable some to survive better in natural conditions (climate, food, physical factors etc.) would outbreed others that are less-endowed to survive under such natural conditions.
- The fitness, according to Darwin, refers **ultimately and only to reproductive fitness**.
- Adaptive ability is inherited and has a genetic basis
- **Fitness is the end result of the ability to adapt and get selected by nature.**
- **Branching descent** and **natural selection** are the two key concepts of Darwinian theory of evolution.
- **Habitat fragmentation** and **genetic drift** may accentuate variations leading to **speciation.**
- **Weaknesses of Darwinism :**
  - (i) Unable to explain the origin of variations
  - (ii) Could not explain speciation
  - (iii) Ignored work done by Mendel.

Mutation theory

- Given by **Hugo de Vries** in first decade of 20th century
- Worked on **evening primrose**
- New species originate as a result of **mutations** which are single step (**saltation**) **large**, **random** and **directionless** variations arising **suddenly** in a population
- **Alfred Wallace**, a naturalist who worked in **Malay Archipelago** had also come to similar conclusions as Charles Darwin around the same time.
- **When we describe story of this world we describe evolution as a process. When we describe the story of life on earth, we treat evolution as a consequence of a process called natural selection.**
- Evolution is **not a directed process** in the sense of determinism. It is a **stochastic process** based on chance events in nature and chance mutations in the organisms.
- **Artificial selection :** By intensive breeding programme, man has created breeds that differ from other breeds (e.g., dogs)

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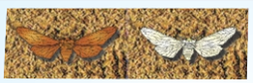
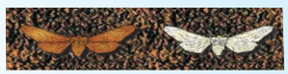
7 EXAMPLES OF EVOLUTION BY ANTHROPOGENIC ACTION

1. Antibiotic resistant microbes
2. Herbicides resistant varieties
3. Pesticides resistant varieties
4. **The case of Industrial melanism :** Classical example of natural selection among variants in **moth population observed in England**.

Parameters	Before industrialisation (1850s)	After industrialisation (1920s)
Figure		
Tree trunks	White, covered by **lichens**	Became dark due to deposition of soot and smoke
White moths	More	Less
Melanised moths	Less	More
Predators feed on	Melanised moths	White winged moths

- Lichens do not grow in polluted area (**pollution indicator**)
- **Agent of natural selection** : Predator/birds
- Moths that were able to camouflage themselves (*i.e.*, hide in the background) survived **but no variant is completely wiped out**

8 A BRIEF ACCOUNT OF EVOLUTION

Form of life	Appeared around
1st non cellular form	3 bya
1st cellular forms	2000 mya
Invertebrates	350 mya
Sea weeds and few plants	320 mya

- Land reptiles were dinosaurs which disappeared 65 mya
  - **Probable reason** → Climatic change
  - **Probable reason** → Evolved in birds
- Some land reptiles went back to water to evolve fish like reptiles eg. *Ichthyosaurus* (200 mya)
- Modern day descendants of reptiles *e.g.*, Turtles, Tortoises, Crocodiles

Lobed fin fish (Coelocanth) → Possibly evolved into → **Amphibians** Frogs, salamanders → Possibly evolved into → **Reptiles** → **Mammals** (Arose from ancestral extinct reptiles)

- Primarily aquatic
- **1938**, fish caught in **South Africa** was earlier thought to be extinct
- Aquatic and land
- **Lay thick shelled eggs which do not dry up in sun**
- **Viviparous** *i.e.*, protect young ones inside mothers body
- More intelligent in sensing and avoiding danger.

- **A Likely Reason for Restricted Distribution of Pouched Mammals in Australia**
  Due to **continental drift**, when South America joined North America, these animals were overridden by North American fauna. Due to the same continental drift pouched mammals of Australia survived because of **lack of competition** from any other mammal.
- The first mammals were like shrews. • Whales, dolphins, seals and sea cows are aquatic mammals.

9 HARDY-WEINBERG PRINCIPLE

- Allele frequencies in a population are stable and is constant from generation to generation. This is called **genetic equilibrium**.
- The **gene pool** (total genes and their alleles in a population) remains a **constant**.
- Sum total of all the allelic frequencies is 1 and is represented as :
  $p + q = 1$ [p = Frequency of recessive allele (a); q = Frequency of dominant allele (A)]
  $p^2 + q^2 + 2pq = 1$ [p^2 = Frequency of homozygous dominant (AA); q^2 = Frequency of homozygous recessive (aa); 2pq = Frequency of heterozygotes (Aa)]
- When frequency measured, differs from expected values, the difference **indicates the extent of evolutionary change** or **disturbance in genetic equilibrium**.
- **Factors affecting Hardy-Weinberg equilibrium :**

1. **Gene migration :** When migration of a section of population to another place or population occurs, gene frequencies change in the original as well as in the new population.

- Emigration (–)
- Some genes/alleles lost
- Immigration (+)
- New genes/ alleles added
- When gene migration occurs multiple times, it is called **gene flow**.

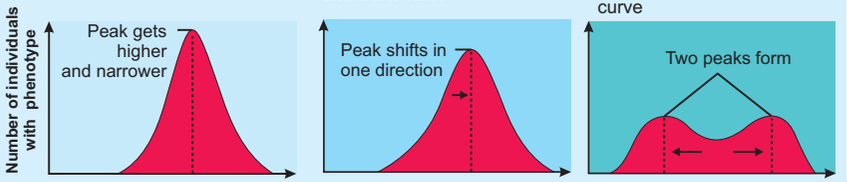
2. **Genetic recombination: Variations due to recombination during gametogenesis**
3. **Mutation:** Microbial experiments show that **pre-existing advantageous** mutations when selected will result in observation of new phenotypes. Over few generations, this would result in speciation.
4. **Genetic drift:** Change in gene frequencies in a small population by chance. Sometimes the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founders and effect is called **founders effect**.
5. **Natural selection** : A process is which heritable variations enabling better survival are enabled to reproduce and leave greater number of progeny.

Types

Stabilising selection
- More individuals acquire mean character value

Directional selection
- More individuals acquire value other than the mean character value

Disruptive selection
- More individuals acquire peripheral character value to both ends at the distribution curve



10 A BRIEF ACCOUNT OF EVOLUTION OF PLANTS

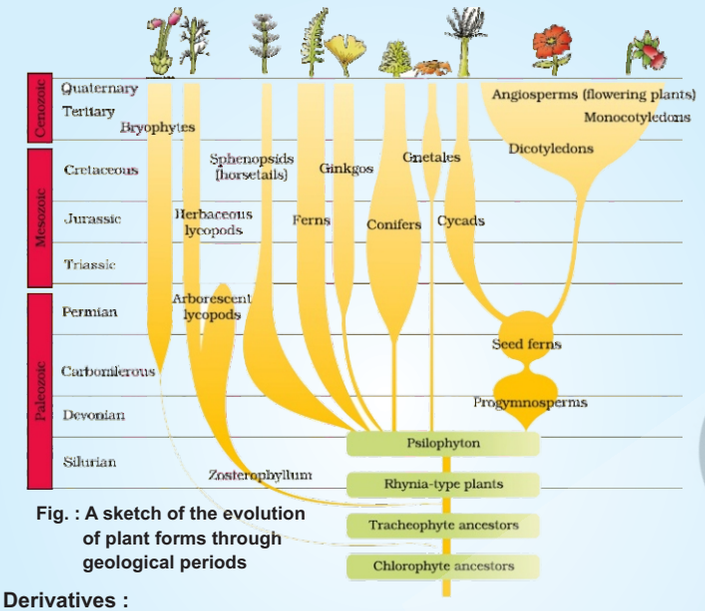


Fig. : A sketch of the evolution of plant forms through geological periods

Derivatives :

- Different types of plants evolved in different periods of time: Palaeozoic, Mesozoic and Coenozoic
- **Chlorophyte ancestors** : Bryophytes : : **Tracheophyte ancestors** : Lycopods
- *Psilophytons* were common ancestors for Progymnosperms, Ferns, Ginkgos, Conifers, Gnetales, Sphenopsids
- **Origin of monocotyledons is more recent than that of dioctyledons**
- Giant ferns (pteridophytes) were present (200 mya) but they all fell to form coal deposits slowly.

11 A BRIEF ACCOUNT OF EVOLUTION HISTORY OF VERTEBRATES

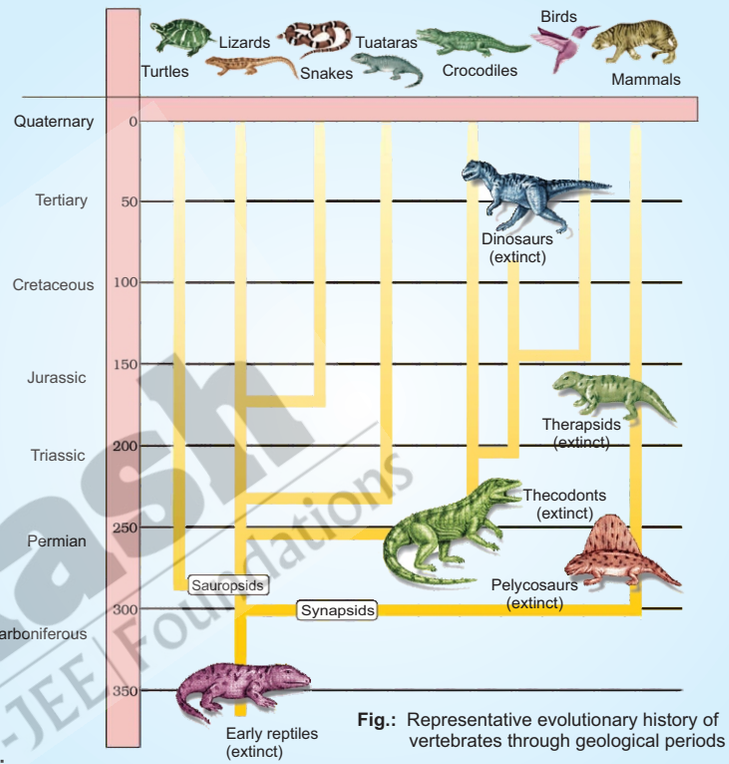
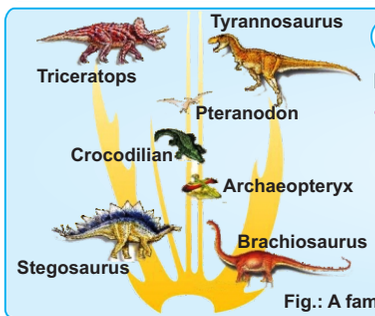


Fig.: Representative evolutionary history of vertebrates through geological periods

Derivatives :

- Turtles, Lizards, Snakes and Tuatara arose from common ancestor **sauropsids**
- **Thecodont** ancestors gave way to existing crocodiles and birds and extinct dinosaurs.
- **Story of origin of mammals** : Extinct reptiles → Synapsids → Pelycosaurs → Therapsids → Mammals

12 A FAMILY TREE OF DINOSAURS



Derivatives :

- ***Triceratops*** – three horned dinosaur with bony frill around back of its head.
- ***Stegosaurus*** – Large triangular bony plates along the back and spiked tail
- ***Tyrannosaurus rex*** – 20 feet in height, had huge fearsome dagger-like teeth
- ***Brachiosaurus*** – Long giraffe like neck, long forelimbs
- ***Pteranodon*** were possibly flying reptiles
- ***Archaeopteryx*** is a transitional fossil between non avian dinosaurs and birds
- ***Brachiosaurus*** and ***Tyrannosaurus*** arose separately, mostly likely, from a common ancestor.

Fig.: A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

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13 ORIGIN AND EVOLUTION OF MAN

- Among the stories of evolution of individual species, the story of evolution of modern man is most interesting and appears to parallel evolution of human brain and language.

Human ancestors	Years back	Cranial capacity	Specific features
Dryopithecus and ***Ramapithecus***	15 mya	–	more ape-like / more man-like: Hairy and walked like Gorillas and Chimpanzees
Australopithecus	2 mya	–	• Few fossils of man-like bones have been discovered in Ethiopia and Tanzania. • 3-4 mya, man-like primates walked in East African grasslands. • They were probably **not taller than 4 feet but walked upright**. • Evidence shows they hunted with stone weapons but **essentially ate fruit**.
Homo habilis	–	650 cc - 800 cc	• **First human-like being, the hominid** • Probably did not eat meat
Homo erectus	1.5 mya	900 cc	• Fossils discovered in **Java in 1891** • Probably ate meat
Neanderthal man	1,00,000-40,000 years back	1400 cc	• Lived in near East and Central Asia • **Used hides to protect their body and buried their dead**
Homo sapiens	75,000-10,000 years ago (ice age)	–	• Arose in Africa and moved across continents and developed into distinct races

- **The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull**

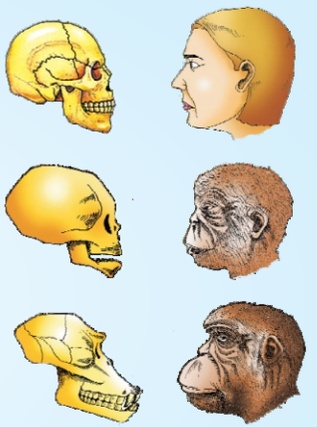

Fig.: A comparison of the skulls of adult modern human being, baby chimpanzee and adult chimpanzee.

- **Pre historic cave art**-18,000 years ago. One such cave paintings by pre-historic humans can be seen at **Bhimbetka rock shelter in Raisen** district of **Madhya Pradesh**.
- **Agriculture** came around **10,000 years back** and human settlements started.

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Sharpen Your Understanding

1. Which theory states that life came out of decaying and rotting matter like straw, mud, etc.? [NCERT Pg. 127]
   (1) Spontaneous generation theory
   (2) Theory of Biogenesis
   (3) Oparin and Haldane hypothesis
   (4) Special Creation theory
2. Read the following statements and choose the **correct** option. [NCERT Pg. 127]
   Statement A : Formation of life was preceded by chemical evolution.
   Statement B : First forms of life could have come from pre-existing non-living organic molecules.
   (1) Only statement A is incorrect
   (2) Only statement B is incorrect
   (3) Both A and B statements are incorrect
   (4) Both A and B statements are correct
3. Spark discharge in Miller's experiment simulated [NCERT Pg. 127, 128]
   (1) Reducing atmosphere
   (2) UV radiations
   (3) Low temperature
   (4) Lightening
4. Which of the following was **not** the connotation of special creation theory? [NCERT Pg. 128]
   (1) All living organisms that we see today were created as such
   (2) Diversity was always the same since creation
   (3) Earth is 4000 million years old
   (4) Diversity will remain same in future
5. The novelty and brilliant insight of Darwin was [NCERT Pg. 135]
   (a) Nature selects those individuals which have variations, which are heritable and which make resource utilization better for few
   (b) Nature selects those individuals which have variations, which enable only those to reproduce and leave more progeny
   (c) Evolution is due to large, directionless variations
   (d) New species arise due to inheritance of acquired characters
   How many of the above statements are **true**?
   (1) One (2) Two
   (3) Three (4) Four
6. Evolution of life forms had occurred due to use and disuse of organs, this theory was given by [NCERT Pg. 134, 135]
   (1) French naturalist Lamarck
   (2) Hugo de Vries
   (3) Charles Darwin
   (4) Alfred Wallace
7. Choose the option that represents artificial selection by anthropogenic action. [NCERT Pg. 131]
   (1) Herbicide resistant varieties
   (2) Industrial melanism
   (3) Antibiotic resistant microbes
   (4) Breeds of dogs created by man
8. When the same structure develops along different directions due to adaptation to different needs, this is A evolution and these structures are B. Choose the option which **correctly** fill the blanks. [NCERT Pg. 130]

	A	B
(1)	Convergent	Homologous
(2)	Divergent	Analogous
(3)	Divergent	Homologous
(4)	Convergent	Analogous

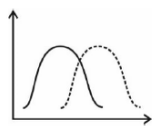
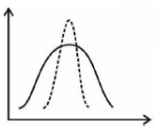
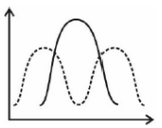
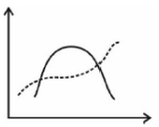
9. Select the option indicating analogous structures. [NCERT Pg. 130, 131]
   (1) Sweet potato and potato
   (2) Thorn of *Bougainvillea* and tendril of *Cucurbita*
   (3) Vertebrate hearts
   (4) Forelimbs of whale, cheetah, bat and man
10. Embryological support for evolution proposed by Ernst Haeckel was disapproved by [NCERT Pg. 129]
    (1) Karl Ernst von Baer
    (2) Karl Landsteiner
    (3) Karl Fischer
    (4) Karl Pearson
11. Select the option which shows embryological evidence of evolution. [NCERT Pg. 130 and 131]
    (1) Fossils in different sedimentary layers
    (2) Vestigial gill slits in embryos of all vertebrates
    (3) Forelimbs of mammals
    (4) Flippers of Penguins and Dolphins

NCERT Based MCQs

12. Which of the following is an **incorrect** statement? [NCERT Pg. 128, 129 and 134]
(1) Populations have built in variation in characteristics
(2) Existing living forms share similarities to varying degrees not only among themselves but also with the life forms that existed millions of years ago
(3) Adaptive ability is not inherited
(4) Fitness is the end result of the ability to adapt and get selected by nature

13. When more individuals acquire peripheral character value at both ends of the distribution curve, this type of natural selection is called [NCERT Pg. 137]
(1) Stabilising selection
(2) Directional selection
(3) Disruptive selection
(4) Progressive selection

14. Select the option which **correctly** represents the distribution curve for industrial melanism. [NCERT Pg. 136]

(1) 
(2) 
(3) 
(4) 

y axis – Number of individuals with phenotype
x axis – character
____ Distribution curve of original population
..... Distribution curve after natural selection

15. If frequency of a dominant allele, in a population which is in genetic equilibrium, is 0.6, then calculate frequency of heterozygotes in that population. [NCERT Pg. 136, 137]
(1) 0.4 (2) 0.24
(3) 0.48 (4) 0.36

16. Match the following columns and choose the **correct** option. [NCERT Pg. 137-140]

	Column-I		Column-II
(a)	Dinosaurs suddenly disappeared	(i)	*Tyrannosaurus rex*
(b)	Fish like reptile	(ii)	65 mya
(c)	Biggest dinosaur	(iii)	*Ichthyosaurs*
(d)	Coelacanth fish	(iv)	350 mya

(1) a–(ii), b-(iii), c-(i), d-(iv)
(2) a–(iv), b-(i), c-(iii), d-(ii)
(3) a–(ii), b-(i), c-(iii), d-(iv)
(4) a–(iv), b-(iii), c-(i), d-(ii)

17. Select the **correct** sequence w.r.t. evolution. [NCERT Pg. 138, 139]
(1) Chlorophyte ancestors → Rhynia-type plants → Seed ferns → Progymnosperms
(2) Progymnosperms → Seed ferns → Cycads → Angiosperms
(3) Sauropsids → Thecodonts → Therapsids → Mammals
(4) Psilophyton → Progymnosperms → Seed ferns → Angiosperms

18. Given below are cranial capacities and features of ancestors of modern man.
Choose the option which is **not** correctly describing the cranial capacity and features of the respective fossil mentioned. [NCERT Pg. 140, 141]

	A	B	C
(1)	*Homo habilis*	650-800 cc	Probably did not eat meat
(2)	*Homo erectus*	900 cc	Fossils discovered in 1891
(3)	Java man	900 cc	Existed around 1.5 mya
(4)	Neanderthal man	1400 cc	Lived in near east and central Africa between 1,00,000-10,000 years back

19. Cave paintings by pre-historic humans can be seen at Bhimbetka rock shelter in [NCERT Pg. 141]
(1) Andhra Pradesh
(2) Madhya Pradesh
(3) Uttar Pradesh
(4) Himachal Pradesh

20. Which of the following is **not** an example of adaptive radiation? [NCERT Pg. 133, 134]
(1) Tasmanian wolf and tiger cat in Australia
(2) Placental mole and placental mouse in Australia
(3) Darwin's finches in Galapagos island
(4) Lemur and spotted cuscus in Australia

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Thinking in Context

1. Stellar distances are measured in _____. [NCERT Pg. 126]
2. _____ is the study of history of life forms on earth. [NCERT Pg. 126]
3. In _____, S.L. Miller, an _____ scientist, created electric discharge in a closed flask containing _____, _____, _____, and _____ at _____ °C. [NCERT Pg. 127]
4. The first non-cellular forms of life could have originated _____ back. They would have been giant molecules like _____, _____, _____ etc. These capsules reproduced their molecules perhaps. [NCERT Pg. 127]
5. The first cellular form of life did not possibly originate till about _____ million years ago. [NCERT Pg. 128]
6. Miller in his experiment, observed formation of _____. [NCERT Pg. 127]
7. Evolution for Darwin was _____ while Hugo de Vries believed _____ caused speciation. [NCERT Pg. 135]
8. Single step large mutation is called _____. [NCERT Pg. 135]
9. The fitness, according to Darwin, refers ultimately and only to _____ fitness. [NCERT Pg. 129]
10. Alfred Wallace, a naturalist who worked in _____ had also come to _____ conclusions as that of Darwin around the _____ time. [NCERT Pg. 129]
11. _____ and _____ are the two key concepts of Darwinian theory of Evolution. [NCERT Pg. 134]
12. The rate of appearance of new forms is linked to the _____ or _____. [NCERT Pg. 134]
13. Darwinian variations are _____ and _____ [NCERT Pg. 135]
14. Five factors are known to affect Hardy Weinberg equilibrium. These are _____, _____, _____, _____, and _____. [NCERT Pg. 137]
15. Evolution is a _____ process based on chance _____ in nature and chance _____ in the organisms. Evolution is not a directed process in the sense of determinism. [NCERT Pg. 132]
16. Before industrialization in England *i.e.*, in_____, _____ moths were more while after industrialization *i.e.*, in _____, _____ moths were more than white winged moths. _____ is completely wiped out. [NCERT Pg. 131 and 132]
17. The process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography is called _____. [NCERT Pg. 133]
18. When more than one adaptive radiation appeared to have occurred in an isolated geographical area (representing different habitats), one can call this _____. [NCERT Pg. 134]
19. Sum total of all the allelic frequencies is _____ [NCERT Pg. 136]
20. When more individuals acquire value other than the mean character value, this type of natural selection is called _____ selection. [NCERT Pg. 137]

❑ ❑ ❑

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Human Health and Disease

5A
Chapter

1 HEALTH

- As per **'Good humor' hypothesis** arrived at by reflective thought and asserted by **Hippocrates** along with **Indian Ayurveda System,**
  Health is a state of body and mind where there was a balance of certain 'humors' *e.g.*, persons with black bile belonged to hot personality and had fevers.
- **William Harvey** (discovered blood circulation experimentally) disproved this 'good humor' hypothesis of health by demonstrating normal body temperature in persons with black bile using thermometer.

View of biologists in later years:

- Mind influences our immune system through neural and endocrine systems, and that our immune system maintains our health *i.e.*, state of complete physical, mental and social and psychological well being.
- Health is not simply 'absence of disease' or 'physical fitness'.

- **Factors affecting health:**
  Mental state, genetic disorders, infections and life style (habits, rest and exercise)
- **Healthy conditions** → Increase → Productivity, longevity; Bring economic prosperity
  Healthy conditions → Decrease → Infant and maternal mortality

2 DISEASE

- It is state of the body when functioning of one or more organ/systems is adversely affected, characterized by various signs and symptoms.

Types of diseases

Parameters	Non-infectious	Infectious
Transmission from one person to another	×	✓
Example	Cancer	AIDS

- **Pathogens**: are disease causing organisms
  - **Most parasites are pathogens** living in (or on) the host multiply and interfere with normal vital activities resulting in morphological and functional damage.
  - Gut pathogens can survive harsh pH & digestive enzymes.

3 CLASSIFICATION OF DISEASES ON THE BASIS OF TRANSMISSION

Mode of transmission	Bacterial	Viral	Protozoan	Helminthic
Air (droplet/aerosol) or **object borne** (pens, knobs *etc.*)	Pneumonia, diphtheria	Common cold, Smallpox	–	–
Direct contact	Tetanus	Smallpox	–	–
Contaminated food and water	Typhoid, dysentery	Polio	Amoebiasis	Ascariasis
Insect vector/vector borne	Plague	Chikungunya, Dengue	Malaria	Filariasis
Body fluids	Syphilis	AIDS	Trichomoniasis	–

- **Vector:** Transmits disease from one organism to another *e.g.* female *Aedes* mosquito is the vector for dengue and chikungunya, while, *Anopheles* spreads malaria.

4 MEASURES FOR PREVENTING SPREAD OF INFECTIOUS DISEASES

Parameters	Measures
Personal Hygiene	Keeping the body clean Consumption of clean drinking water, food, vegetables, fruits etc.
Public Hygiene	Proper disposal of waste and excreta Periodic cleaning and disinfection of water reservoirs, pools, cesspools and tanks. Decontamination of drinking water
Avoid close contact	Contact with infected persons and belongings should be avoided.
Control vectors and their breeding places	Avoid stagnation of water in and around residential areas. Regular cleaning of house old coolers Use of mosquito nets Introducing **larvicidal fishes** like *Gambusia* in ponds that feed on mosquito larvae Spraying of insecticides in ditches, drainage areas and swamps Doors and windows should be provided with wire mesh.

- Balanced diet, yoga and regular exercise, personal hygiene, awareness about diseases and vaccination are very important to **maintain good health**.
- Use of vaccines and immunisation programmes have enabled us to **completely eradicate a deadly disease like smallpox**. Large number of infectious diseases like polio, diphtheria, pneumonia and tetanus have been controlled to a large extent by the use of vaccines.
- Biotechnology is at the verge of making available newer and safer vaccines.
- Discovery of antibiotics and various drugs have enabled us to effectively treat infections

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5 BACTERIAL DISEASES

Disease	Pathogen	Organ affected	Common symptoms
Typhoid	*Salmonella typhi* **Diagnostic test: Widal test**	Small intestine and other organs by migrating through blood	**Sustained high fever (39-40°C)** Stomach pain ○ Weakness Constipation ○ Headache Loss of appetite **In severe cases, intestinal perforation and death** may occur.
Pneumonia	*Streptococcus pneumoniae*, *Haemophilus influenzae*	Alveoli of lungs	Problem in respiration due to fluid filled alveoli Fever, chills, cough, headache **In severe cases, lips and finger nails turn gray to bluish**

Typhoid Mary (Mary Mallon), a cook by profession was a **typhoid carrier** who spread typhoid through the food she prepared.

VIRAL DISEASES

Disease	Pathogen	Organ affected	Symptoms
Common cold	Rhino virus	Nose and respiratory passage	Nasal congestion and discharge Sore throat Hoarseness, cough Headache, tiredness

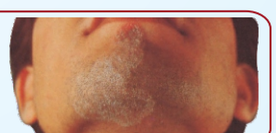
Common cold does not infect lungs and its symptoms usually lasts for 3-7 days

HELMINTHIC DISEASES

Disease	Pathogen	Organ/structure affected	Symptoms
Ascariasis	*Ascaris* **(Roundworm)**	Intestine	Internal bleeding, fever, muscular pain, anemia, **blockage of intestinal passage**
Elephantiasis /Filariasis	*Wuchereria bancrofti/ W. malayi* **(Filarial worm)**	Lymphatic vessels	**Chronic inflammation** of organs in which they live for many years resulting in gross deformities *e.g.*, limbs, genital organs etc.

FUNGAL DISEASE

Disease	Pathogen	Body parts affected	Symptoms
Ringworm	*Microsporum*, *Trichophyton*, *Epidermo-phyton*	Skin, nails, scalp	Dry, scaly lesions Intense itching



Heat and moisture makes the fungi thrive in **skin folds** such as in groin and between toes
Acquired from soil or belongings of infected individuals such as towels, combs, clothes *etc.*

6 PROTOZOAN DISEASES

Disease	Pathogen	Area affected	Symptoms
Amoebiasis /Amoebic dysentery	*Entamoeba histolytica*	Large Intestine	Constipation Abdominal pain Cramps **Stool with excess mucous and blood clots**
Malaria	*Plasmodium* *P. vivax* *P. malariae* *P. falciparum*	RBCs	Chills High fever recurring every 3-4 days If not treated, can prove to be fatal

House flies act as mechanical carrier for amoebiasis
***P. falciparum* causes malignant malaria (Most serious form)**

LIFE CYCLE OF *PLASMODIUM*

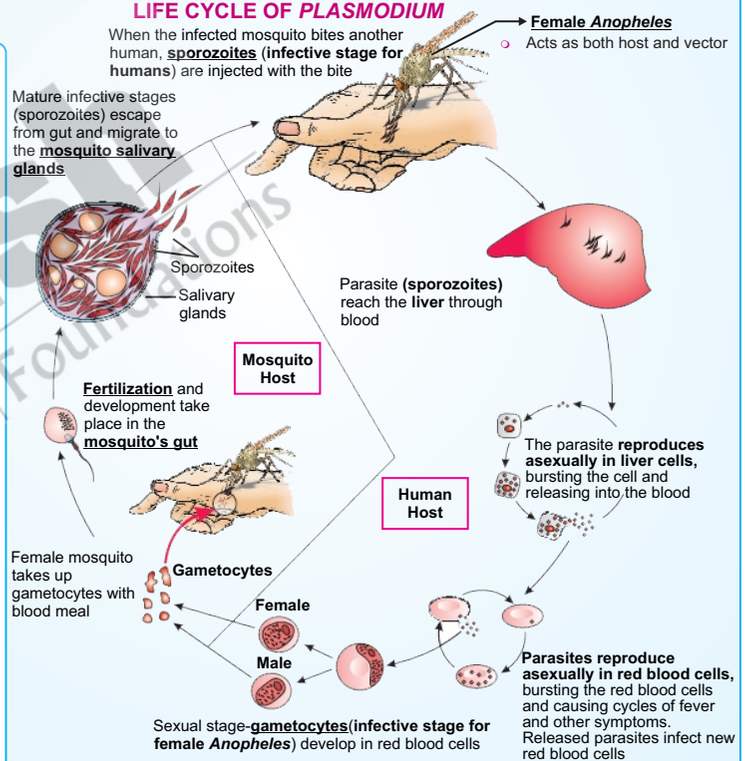

Female Anopheles
Acts as both host and vector
When the infected mosquito bites another human, sporozoites (infective stage for humans) are injected with the bite
Mature infective stages (sporozoites) escape from gut and migrate to the mosquito salivary glands
Sporozoites
Salivary glands
Parasite (sporozoites) reach the liver through blood
Mosquito Host
Fertilization and development take place in the mosquito's gut
The parasite reproduces asexually in liver cells, bursting the cell and releasing into the blood
Human Host
Female mosquito takes up gametocytes with blood meal
Gametocytes
Female
Male
Parasites reproduce asexually in red blood cells, bursting the red blood cells and causing cycles of fever and other symptoms. Released parasites infect new red blood cells
Sexual stage-gametocytes(infective stage for female Anopheles) develop in red blood cells

Fig: Stages in the life cycle of *Plasmodium*

Rupturing of RBCs releases the toxic substance, **haemozoin** responsible for symptoms of disease

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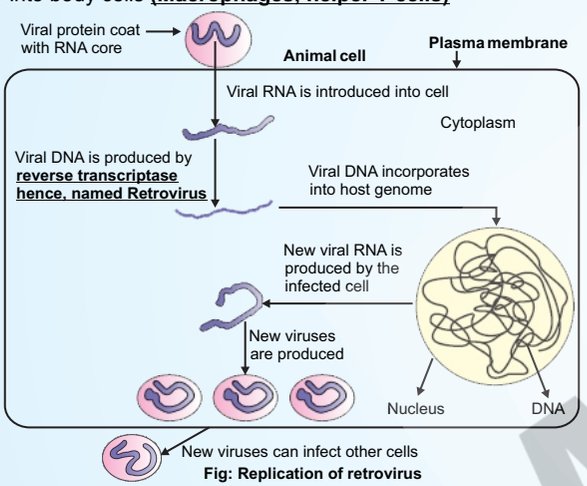
7 AIDS/ACQUIRED IMMUNO DEFICIENCY SYNDROME

- 1st reported - 1981, Killed – Approximately 25 million people in last 25 years
- It is deficiency of immune system, acquired during the lifetime of an individual
- **Syndrome** means 'group of symptoms'
- **Non congenital, fatal infectious disease**
- **Causative agent** – HIV / Human Immuno deficiency virus
  - ↳ **Enveloped virus enclosing RNA genome**
- **Life cycle**

Mode of Transmission	High Risk Individuals
Sexual contact	Multiple sexual partners
Placenta	Mother to foetus
Blood transfusion	Repeated blood transfusion, Drug addicts **(intravenous)**
Infected needles	

Entry of virus in body → Entry into body cells **(Macrophages, helper T-cells)**


Viral protein coat with RNA core
Animal cell
Plasma membrane
Viral RNA is introduced into cell
Cytoplasm
Viral DNA is produced by reverse transcriptase hence, named Retrovirus
Viral DNA incorporates into host genome
New viral RNA is produced by the infected cell
New viruses are produced
Nucleus
DNA
New viruses can infect other cells
Fig: Replication of retrovirus

Sequence of events:

- Infected cells, **(Macrophages)** can survive while viruses are being replicated and released **hence called HIV factory**
- HIV enters into macrophages and T-helper cells (T_H) simultaneously
- There is progressive decrease in number of helper T-cells.
- **Initial symptoms:** Bouts of fever, diarrhoea, weight loss
- **Later the immuno-deficient patient** is prone to infections especially *Mycobacterium,* viruses, fungi, *Toxoplasma* etc.

There is always a time-lag between infection and appearance of AIDS symptoms. This may vary from a few months to many years (usually 5-10 years)

Diagnostic Test

- **ELISA** (Enzyme Linked Immuno Sorbent Assay)

Treatment

- **Anti-retroviral drugs**, can only prolong life but cannot prevent death

8 CANCER

- A dreaded **non-infectious** disease; major cause of death all across the globe.

Parameters	Normal cells	Cancerous cells/Neoplastic cells
Cell growth and differentiation	Highly controlled and regulated	Uncontrolled & non-regulated
Contact inhibition	**Present**, virtue of which contact with other cells inhibits their growth	**Lost**, so these cells keep on dividing and form mass of cells called **Tumor/Neoplasm**

Types of Tumor

Parameters	Benign	Malignant tumor/cancer
Location	Confined to original place	Grow rapidly and spread to other parts
Damage	Little damage	Invade and damage other cells starving normal cells by competing for vital nutrients.
Metastasis	**No**	**Yes**, Cells sloughed from such tumors reach distant sites through blood and start new tumor called **Metastasis (Most feared property)**.

Cause: Proto/cellular oncogene (*c-onc*) (**Normal cell**) → Neoplastic transformation → Oncogene (**Cancerous cell**)

causative agents called **carcinogens**

- **Ionising radiations**-X-rays, γ - rays • **Non-ionising radiations**-UV rays • **Physical agents**
- **Chemical agents**-in tobacco smoke • **Biological agents**-Oncogenic viruses **(carry viral oncogenes)**
- **Diagnosis/Detection:** Early detection allows the disease to be treated successfully in many cases.

Technique	Basis	Detect
Biopsy	Histopathological studies	Changes in tissue
Blood and bone marrow test	Cell counts	Leukemias
Radiography	X-rays	Internal organ cancers
Computed tomography **(CT)**	X-rays	Internal organ cancers **(3D image)**
Magnetic resonance Imaging **(MRI)**	Strong magnetic fields and non-ionising radiations	Accurately detect pathological and physiological changes in living tissue
Molecular techniques	Identification of genes responsible for susceptibility to certain cancers	
Antibodies based	Against cancer specific antigens	Certain cancers

- **Tumor cells have ability to avoid detection and destruction by immune system.**
- **Approaches for treatment:**
  - Surgery
  - Radiotherapy: Tumor cells irradiated lethally
  - Chemotherapy: Side effects like hair loss, anemia
  - Immunotherapy: **α-Interferons** (Biological response modifiers) activate immune system and helps in destroying the tumor.

Prevention

- Different agencies like NGOs, NACO, WHO started number of programmes to educate/make people aware of AIDS **(Don't die of ignorance)** and some of the measures preventing spreading of HIV infection.
- **Making blood banks safe** from HIV
- **Use of only disposable needles and syringes** in public and private hospitals and clinics
- **Free distribution of condoms,** advocating safe sex
- **Controlling drug abuse**

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Sharpen Your Understanding

1. Who among the following is responsible for disproving the 'good humor' hypothesis of health? [NCERT Pg. 145]
   (1) Hippocrates (2) Charles Darwin
   (3) William Harvey (4) Stanley Miller
2. Health is badly affected by all **except** [NCERT Pg. 145]
   (1) Genetic disorders
   (2) Infections
   (3) Quality and quantity of food and water we take
   (4) Maintaining life style with exercise and sufficient rest
3. Read the given statements
   Statement-I : Health was considered as a state of body and mind where there was a balance of certain 'humors'.
   Statement-II : Both neural system and endocrine system help in maintaining our health by influencing immune system
   Select the **correct** option. [NCERT Pg. 145]
   (1) Only statement I is correct
   (2) Only statement II is correct
   (3) Both statements are correct
   (4) Neither statement I nor II is correct.
4. Among following, one of the most dreaded non-infectious disease is [NCERT Pg. 146]
   (1) Common cold (2) AIDS
   (3) Cancer (4) Malaria
5. Select the **correct** match w.r.t disease listed in column I with corresponding causative agent in column II [NCERT Pg.147]

Column-I	Column-II
(1) Typhoid	*E.coli*
(2) Malaria	Male *Anopheles*
(3) Common cold	Rhinovirus
(4) Filariasis	Male *Culex*

6. Choose the **odd** one w.r.t bacterial diseases [NCERT Pg. 147]
   (1) Dysentery
   (2) Plague
   (3) Typhoid
   (4) Malignant malaria
7. Infective stage of *Plasmodium* for humans resides in which region in the vector? [NCERT Pg.147]
   (1) Midgut
   (2) Salivary glands
   (3) Liver (hepatocytes)
   (4) Erythrocytes
8. In the box given below, how many diseases are caused by protozoans?

Malaria, Pneumonia, Common cold, Amoebic dysentery, Ascariasis, Elephantiasis

   [NCERT Pg. 148]
   (1) Zero (2) One
   (3) Two (4) Three

NCERT Based MCQs

9. A patient complaining of ache in the abdomen visited the doctor. The doctor following observed signs
   I. Internal bleeding
   II. Fever
   III. Muscular pain
   IV. Anemia
   V. Blockage of intestinal passage
   The patient is most likely suffering from [NCERT Pg.149]
   (1) Filariasis
   (2) Amoebic dysentery
   (3) Ringworm
   (4) Ascariasis
10. Mosquitoes are not involved in the spread of disease caused by [NCERT Pg.150]
    (1) *Entamoeba histolytica*
    (2) Chikungunya virus
    (3) *Wuchereria malayi*
    (4) Dengue virus
11. Widal test is used to confirm that a person has typhoid fever. This disease shares its mode of transmission with [NCERT Pg.147]
    (1) Ascariasis
    (2) Filariasis
    (3) Chikungunya
    (4) Pneumonia

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12. Select the **mismatch** w.r.t mode of transmission [NCERT Pg.149]

(1)	Dengue and chikungunya	*Aedes* mosquito
(2)	*Microsporum* and *Epidermophyton*	Acquired from bite of *Culex* mosquito
(3)	Common cold and diphtheria	Droplet infection
(4)	Ascariasis and amoebiasis	Faeco-oral route

13. Gametocytes are formed in which of the following during the life cycle of *Plasmodium*? [NCERT Pg.148]

(1) Erythrocytes of human blood

(2) Salivary glands of mosquito

(3) Hepatocytes of humans

(4) Haemocytes of *Anopheles*

14. Appearance of dry, scaly lesions on various parts of body such as skin, nails and scalp indicate infection by all **except**

NCERT Pg.149]

(1) *Microsporum*

(2) *Trichophyton*

(3) Roundworms

(4) *Epidermophyton*

15. Choose the parasite of large intestine of humans whose mechanical carrier are houseflies [NCERT Pg.148]

(1) *E. histolytica*

(2) *E. coli*

(3) *W. bancrofti*

(4) *P. falciparum*

16. Choose the **incorrect** statement

[NCERT Pg. 150]

(1) Spread of chikungunya cannot be controlled by introduction of *Gambusia* in local water bodies

(2) Lymphatic vessels are blocked by infection of *Wuchereria*

(3) Vaccines have enabled us to control the spread of polio, diphtheria and pneumonia to a large extent.

(4) Gametes formed in the life cycle of *Plasmodium* fuse in mosquitoes gut

17. Select the **incorrect** statement among following. [NCERT Pg.146]

(1) Healthy conditions decrease longevity of people and reduce maternal and infant mortality

(2) Health does not simply imply 'absence of disease'

(3) When people are healthy, they are more efficient at work

(4) Health can be defined as a state of complete physical, mental and social well being

18. Cases of people suffering from acquired immunodeficiency syndrome were first reported in [NCERT Pg.154]

(1) 1983

(2) 1981

(3) 1951

(4) 1971

19. Drastic decline in number of which cells is a major cause of AIDS? [NCERT Pg.156]

(1) Cytotoxic T cells

(2) Helper T cells

(3) Thrombocytes

(4) B cells

20. Method/technique utilizing X-rays to generate three dimensional image of the internal organs of an object is

[NCERT Pg.157]

(1) MRI

(2) ELISA

(3) Computed tomography

(4) Biopsy

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Thinking in Context

1. Normal cells show a property of _____ by virtue of which contact with other cells inhibits their uncontrolled growth. [NCERT Pg.157]
2. _____ is the property by which cells sloughed from primary tumors reach distant sites. [NCERT Pg.157]
3. Chemical carcinogens present in tobacco smoke have been identified as a major cause of _____ cancer. [NCERT Pg.157]
4. _____ genes identified in normal cells which when activated under certain conditions could lead to oncogenic transformation of cells. [NCERT Pg.157]
5. In _____, a piece of suspected tissue cut into thin sections is stained and examined by under microscope by a pathologist. [NCERT Pg.157]
6. In cancer, the patients are given substances called biological response modifiers such as _____ which activates their immune system and helps in destroying the tumor. [NCERT Pg.158]
7. An organisation that helps to spread awareness about AIDS and spreads the message 'don't die of ignorance' is_____. [NCERT Pg.156]
8. A widely used diagnostic test for AIDS is _____. [NCERT Pg.156]
9. Immunodeficient person can suffer from infections of *Mycobacterium*, viruses, fungi and even protozoans like _____. [NCERT Pg.156]
10. Deficiency of immune system, acquired during the lifetime of an individual indicates that AIDS is not a _____ disease. [NCERT Pg.154]
11. HIV/AIDS is not spread by mere touch or physical contact, it spreads only through _____. [NCERT Pg. 155]
12. HIV is a retrovirus as it transcribes through process of _____. [NCERT Pg.156]
13. High risk of HIV infection is observed in case of drug addicts who take drugs _____. [NCERT Pg.155]
14. HIV is a retrovirus whose _____ genome is protected by envelop of proteins. [NCERT Pg. 154]
15. Maintaining public hygiene is essential to prevent spread of diseases transmitted through _____ such as typhoid, amoebiasis and ascariasis. [NCERT Pg. 149]
16. Chronic inflammation of the lymphatic vessels of the lower limbs and also genital organs is seen in disease _____. [NCERT Pg. 149]
17. In a person infected by sporozoites of *Plasmodium*, the rupture of RBCs is associated with release of a toxic substance _____ responsible for chills and recurring fever. [NCERT Pg. 147]
18. Most parasites can be considered _____ as they cause harm to the host by living in or on them. [NCERT Pg. 146]
19. As a result of infection with *H.influenzae*, the alveoli get filled with fluid leading to severe problems in respiration if a person is suffering from _____. [NCERT Pg. 147]
20. The use of vaccines and immunization programmes have enabled us to completely eradicate a deadly disease like _____. [NCERT Pg. 150]

❑ ❑ ❑

Human Health and Disease

5B
Chapter

1 IMMUNITY

- The ability of the host to fight the disease causing organisms, conferred by the immune system is called **Immunity**

Types

Parameters	Innate	Acquired
Observed from	Time of birth	After birth
Exposure to infection	Not required	Required
Defence	Non specific	Specific
Memory record	×	✓

Memory based immunity evolved in higher vertebrates

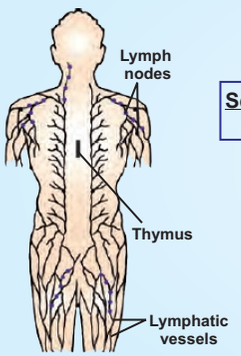
2 INNATE IMMUNITY

- This immunity is accomplished by providing different types of barriers to the entry of the foreign agents.

Types of Barrier	Structures involved/Barrier	Basic function
Physical	○ Skin ○ Mucus coating of the epithelium lining the respiratory, gastrointestinal and urogenital tracts	○ Prevent entry of microbes ○ Trap microbes entering our body
Physiological	○ Saliva in the mouth ○ Acid in stomach ○ Tears from eyes	○ Prevent microbial growth
Cellular	○ Neutrophils/PMNL ○ Monocytes ○ Macrophages ○ Natural killer cells (type of lymphocytes)	○ Phagocytose microbes ○ Destroy microbes
Cytokine	○ Interferons	○ Produced by virus infected cells that protect **non-infected cells** from further infection

3 ACQUIRED IMMUNITY

- The human immune system consists of lymphoid organs, tissues, cells and soluble molecules like antibodies. This response is carried out by two special types of lymphocytes present in our blood *i.e.*, **B and T-lymphocytes.**



Primary lymphoid organs

Thymus — Bone marrow

↓ Matured lymphocytes migrate

T-cells — B-cells

Secondary lymphoid organs

Spleen, lymph nodes, tonsils, appendix, MALT, Peyer's patches

T-cells mediated response → Help → B-cells produce antibodies/Army of proteins in blood

- **Cell-mediated immune response/CMI**
- **Humoral immune response/Antibody mediated immune response**

- Origin and/or maturation of lymphocytes
- **lymphocytes become antigen sensitive**
- Provide micro-environments for development and maturation of lymphocytes
- Provide sites for interaction of lymphocytes with antigen which proliferate to become **effector cells**.

IMMUNE RESPONSE

- **Type** — **Primary**: First time; **Secondary/Anamnestic**: Subsequent times
- **Exposure to pathogens**
- **Intensity**: Low → High (Based on memory of first encounter)

These responses are carried out by B and T lymphocytes.

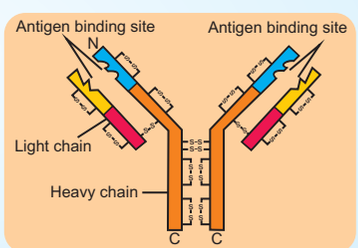


Fig: Structure of an antibody molecule

- Each antibody has 4 peptide chains **(H_2L_2)**
  - 2 long heavy chains
  - 2 short light chains
- Called immunoglobulins (Ig)
- **Types – IgA, IgM, IgE, IgG**

- T-lymphocytes are responsible for graft rejection. Tissue and blood group matching are essential before undertaking any graft/transplant and even after this patient has to take immunosuppressants throughout life.
- If the pathogens succeed in gaining entry to our body, specific antibodies and T-cells serve to kill these pathogens.

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4 LYMPHOID STRUCTURES/ORGANS

Structure	Typical
Bone marrow	○ **Main lymphoid organ** where all blood cells are produced including lymphocytes.
Thymus	○ **Lobed** organ located **near the heart** and **beneath the breastbone**. Quite large at the time of birth, **keeps reducing in size** with age and by the time puberty is attained it is reduced to a very small size.
Spleen	○ Large **bean shaped organ**, mainly contains lymphocytes and phagocytes • Acts as a **filter of the blood** by trapping blood borne micro-organisms • **Large reservoir of erythrocytes.**
Lymph nodes	○ Small solid structures located at different points along the lymphatic system ○ Serve to **trap the microbes/antigens** which happen to get into the lymph and tissue fluid. Antigens trapped in the lymph nodes are responsible for the **activation of lymphocytes** present there and cause the immune response.
MALT	○ Mucosa-associated lymphoid tissue is located within the lining of major tracts like respiratory, digestive and urinogenital tracts ○ Constitutes about **50%** of lymphoid tissue in human body.

6 ALLERGIES

Exaggerated response of immune system to certain antigens present in the environment.

Allergens – Substances to which exaggerated immune response is produced e.g. pollens, mites in dust, animal dander, etc.

Antibodies – **IgE type**

Symptoms – Sneezing, watery eyes, running nose, difficulty in breathing

Chemical released – **Histamine** and **serotonin** from mast cells

Diagnosis – Patient is exposed to or injected with very small doses of possible allergens, and reactions studied.

Treatment – Anti-histamine antihistamine, adrenaline and steroids quickly reduce the symptoms of allergy

Effects of modern-day life style

- Protected environment provided early in life has resulted in lowering of immunity and person is more sensitive to allergens
- More and more children in metro cities of India suffer from allergies and asthma due to more sensitivity to the environment

5 VACCINATION AND IMMUNISATION

Types of immunity

	Active	**Passive**
Antibodies	Produced within the host body	Ready-made/preformed antibodies are directly given
Time taken for full/ effective response	Longer	Shorter
Memory cells	✓	✗
Examples	○ Natural infection → Antibody production in host ○ **Vaccination** – Deliberate injection of living/ dead microbes/proteins	○ Mother —Placenta→ Foetus ○ Mother —Colostrum (IgA)→ Infant

Immunisation
(Principle : Property of 'Memory' of immun system)

Active
Preparation of antigenic proteins of pathogen/inactivated /weakened pathogen introduced into body

Passive
Direct preformed antibodies/antitoxin is injected such as antitoxin against snake bites

- The antibodies produced in the host body against antigens would neutralize the pathogenic agents during actual infection.
- The vaccines also generate **memory B-cells and memory T-cells** that recognise the pathogen quickly on subsequent exposure and overwhelm the invaders with a massive production of antibodies.
- **Recombinant DNA technology** has allowed the large scale production of antigenic polypeptides of pathogen in **bacteria/yeast**, hence greater availability for immunisation.
  e.g., **hepatitis B vaccine produced from yeast.**

7 AUTOIMMUNITY

○ Memory based acquired immunity evolved in higher vertebrates can **distinguish foreign** molecules as well as foreign organisms (pathogens) **from self-cells**.

If lost this ability

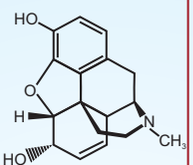
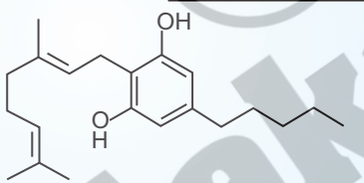
Results – Self **destruction**/body attack self cells

Reason – Genetic/unknown

Example – **Rheumatoid arthritis**

8 DRUG ABUSE

- Chemical when taken for a purpose other than medicinal use or in amounts/ frequency impairs one's physical, physiological or psychological functions and constitutes **drug abuse**.
- **Source** - Majorly from flowering plants and some from fungi.
- Commonly abused drugs are:

Drug	Receptors	Source	Intake	Examples	Action and anything specific
Opioids	CNS, GIT	Latex of poppy plant, *Papaver somniferum* Opium poppy	Snorting, injection  Chemical structure of Morphine	• Morphine • Heroin/Smack (Diacetylmorphine)	• Effective sedative and pain killer • Useful in patients undergone surgery • Depressant and slows down body functions • Odourless, white, bitter crystalline compound
Cannabinoids	Principally in brain	Inflorescence, flower tops, leaves and resin of cannabis plant, *Cannabis sativa* Leaves of *Cannabis sativa*	Inhalation, oral ingestion  Skeletal structure of cannabinoid molecule	• Charas • Hashish • Ganja • Marijuana	• Effects on cardiovascular system of the body • These days cannabinoids are formating also being abused by some sportspersons
Stimulants	CNS	Coca plant *Erythroxylum coca* (Native of South America)	Snorting	• Cocaine/coka alkaloid • Commonly called (coke/crack)	• Interferes with transport of neurotransmitter dopamine • Potent stimulating action on CNS, producing **sense of euphoria** and increased energy • **Excessive dosage causes hallucinations**
Hallucinogens		*Atropa belladona, Datura* Flowering branch of *Datura*			• Have been used for hundreds of years in folk-medicine, religious ceremonies and rituals all over the globe.
Other drugs		Synthetic		Barbiturates, Benzodiazepines, Amphetamines	• Help patients cope with mental illness like **depression insomnia**.

9 DRUGS AND SPORTSPERSON

Why to use?

- Increase muscle strength & bulk
- Promote aggressiveness
- Enhance athletic performance

Commonly abused drugs

- Narcotic analgesics
- Diuretics
- Anabolic steroids
- Certain hormones

Common side effects

- Increased aggressiveness
- Mood swings
- Depression
- Stunted growth because of premature closure of growth centres of long bones
- Severe facial and body acne

Typical side effects

Male

- **Breast enlargement**
- Decreased sperm production
- Reduction in size of testicles
- Acne, premature baldness, enlargement of prostate gland
- Potential for liver and kidney dysfunction

Female

- **Masculinisation** (features like males)
- Abnormal menstrual cycles
- Enlargement of clitoris
- Excessive hair growth on face & body
- Deepening of voice

- These side effects may be permanent with prolonged use.

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10 TABACCO/SMOKING-PAVES THE WAY TO HARD DRUGS

- **Intake** – Smoked, Chewed, Snuff
- **Chemical substance** – **Nicotine, an alkaloid**
- **Action of nicotine** – Stimulates adrenal gland to release adrenaline and non-adrenaline into blood circulation.

Effects

- **Respiratory system** – Increases carbon monoxide (CO) in blood and reduces concentration of haembound oxygen, causes oxygen deficiency in the body
- **Circulatory system** – Increase heart rate and blood pressure.
- **Common diseases** – Bronchitis, Emphysema, Coronary heart disease, Gastric ulcer
- **Risk of cancers** – Oral cavity, Throat, Lungs, Urinary bladder

- Tobacco has been used by humans for more than 400 years
- Packets of cigarettes, warns against smoking and says how it is injurious to health.

11 ADOLESCENCE AND DRUG/ALCOHOL ABUSE

- **Adolescence** means both "**a period**" and "a **process**" during which a child mature in terms of his/her attitudes and beliefs for effective participation in society.
- Adolescence is a **bridge linking childhood and adulthood.**
- It's a period between **12-18 years of age,** a **vulnerable phase of mental** and **psychological development** of an individual.
- It is accompanied by several biological and behavioural changes.
- Curiosity, need for adventure and excitement, and experimentation, motivate youngsters towards drug and alcohol use.
- First use may be out of curiosity but later used to escape from stress, pressures to excel in academics, perception that it is cool.
- Television, movies, newspapers, internet, **promote** this perception.
- Unstable or unsupportive family structures and peer pressure also promote drug and alcohol abuse.

Use of durgs even once can be **"fore-runner to addiction"** and pull the user into a vicious circle leading to their regular use/abuse.

12 ADDICTION AND DEPENDENCE

Addiction

- Because of perceived benefits, drugs are frequently used repeatedly that leads to **psychological attachment to certain effects** like euphoria and temporary feeling of well being

Dependence

It is the tendency of the body to manifest a characteristic and unpleasant "withdrawal syndrome" if regular dose of drugs/alcohol is abruptly discontinues.

Addiction drive people to take drug even when its use become self-destructive

- **With repeated** use of drug, **tolerance level of receptors increases**
- Receptors respond only to higher doses of drugs leading to greater intake.

Effects of drug/alcohol abuse

- Reckless behaviour. Vandalism Violence Depression Fatigue Drop in academic performance
- **Warning signs:**
  - Unexplained absence from school/college
  - Aggressive and rebellious behaviour
  - Change in sleeping and eating habits
  - Deteriorating relationships with family and friends
  - Poor personal hygiene, withdrawal, isolation
  - Loss of interest in hobbies
  - Fluctuations in weight and appetite
- High doses lead to **coma** and **death** due to respiratory failure, heart failure or cerebral hemorrhage
- Chronic use of drugs/alcohol damage **nervous system and liver (cirrhosis)**
- Use of drugs during pregnancy **adversely affect foetus.**

Some far-reaching implications

- Abuser may turn to stealing
- Addict becomes the cause of mental and financial distress to entire family and friends

Withdrawl syndrome

If drug is abruptly discontinued, symptoms include:

- Anxiety Nausea Shakiness Sweating
- In severe cases, can be life threatening, person needs a medical supervision.

Prevention and control

"Prevention is better than cure"

- **Avoid undue peer pressure** on child related to sudies, sports or other activities
- **Education and counselling:** Channelise energy of child into healthy pursuits like sports, yoga, reading, music, etc.
- Sort out problems by **seeking help from parents and peers.**
- **Looking for danger signs** :Alert parents, teachers and close friends need to look for and identify the danger signs of substance (drug/alcohol) abuse and appropriate measures would then be required to diagnose the malady and underlying cause.
- Proper remedial steps or treatment should be taken by **seeking professional and medical help** in the form of highly qualified psychologists, psychiatrists and de-addiction and rehabilitation programmes. This will totally relieve the individual from these evils.

Sharpen Your Understanding

1. Which of the following organ act as filter of blood by trapping blood borne micro-organisms? [NCERT Pg. 154]
   (1) Bone marrow
   (2) Liver
   (3) Spleen
   (4) Thymus

2. Read the following statements and choose the **correct** option [NCERT Pg. 153]
   Statement-A : Allergy is due to the release of chemicals like histamine and serotonin from the mast cells.
   Statement-B : The use of drugs like antihistamine, adrenaline and steroids, quickly reduce the symptoms of allergy.
   (1) Both statement A and B are incorrect
   (2) Both statement A and B are correct
   (3) Only statement A is correct
   (4) Only statement B is correct

3. Cellular barriers of innate immunity include all, **except** [NCERT Pg. 151]
   (1) Neutrophils
   (2) Monocytes
   (3) NK cells
   (4) Interferons

4. Antitoxin is [NCERT Pg. 152]
   (1) Detoxified toxin
   (2) Strong toxin
   (3) Preformed antibodies
   (4) Neutralised toxin

5. Recombinant DNA technology has allowed the production of hepatitis-B vaccine. Which host is used for this preparation? [NCERT Pg. 152]
   (1) *E.coli*
   (2) Yeast
   (3) *Drosophila*
   (4) Mycoplasma

6. In case of snake bite, the patient is given an antivenom injection. This is a case of [NCERT Pg. 152]
   (1) Active immunisation
   (2) Passive immunisation
   (3) Innate immunity
   (4) Natural immunisation

7. Secondary immune response is **not** [NCERT Pg. 151]
   (1) Rapid in action
   (2) Long lasting
   (3) Seems to occur at subsequent exposure of host to the same antigen
   (4) Known for acquiring long time to establish immunity

NCERT Based MCQs

8. Which of the following is the common feature shared by benzodiazepines and barbiturates? [NCERT Pg. 159]
   (1) Stimulants
   (2) Medicine for insomnia
   (3) Snorted
   (4) Pain relievers

9. Match drugs in column I with their source in column II and choose the **correct** answer [NCERT Pg. 159]

Column-I	Column-II
I. Cocaine	a. *Cannabis sativa*
II. Charas	b. *Papaver somniferum*
III. Morphine	c. *Erythroxylum*

	I	II	III
(1)	c	a	b
(2)	c	b	a
(3)	b	a	c
(4)	a	b	c

10. Which of the following drug is very effective sedative and painkiller and is very useful in patients who have undergone surgery? [NCERT Pg. 159]
    (1) Hashish
    (2) Morphine
    (3) Amphetamine
    (4) Barbiturate

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11. Which of the given functions is **not** directly performed by T-lymphocytes? [NCERT Pg. 151]

(1) Antibody formation
(2) Graft rejection
(3) Kill virus-infected cells
(4) Keeping memory record of first encounter

12. Which of the following is **not** true for acquired immunity? [NCERT Pg. 151]

(1) Specific in nature
(2) Found in vertebrates
(3) Characterised by memory
(4) Involve all nucleated leukocytes

13. Select the **incorrect** statement w.r.t. interferon [NCERT Pg. 151]

(1) They are proteins
(2) They are classified as cytokines
(3) Secreted by non-virus infected cells to protect themselves
(4) Secreted by virus infected cells to protect the non-infected cells from viral infection

14. Physiological barrier that prevent microbial growth **exclude** [NCERT Pg. 150]

(1) Acid in stomach
(2) Saliva in mouth
(3) Mucus coating of the epithelium lining the urinogenital tract
(4) Tears in eyes

15. Primary exposure to antigenic proteins of the pathogen may result in the production of all **except** [NCERT Pg. 151]

(1) Antibodies
(2) B-memory cells
(3) T-memory cells
(4) Acid in stomach

16. Select the 'X' to complete the analogy

- Immature lymphocytes: Differentiate into antigen specific lymphocytes in primary lymphoid organs.
- Mature lymphocytes: Undergo proliferation and differentiation in 'X'

[NCERT Pg. 154]

(1) Primary lymphoid organ
(2) Secondary lymphoid organ
(3) Bone marrow
(4) Thymus

17. Highest density of opioid receptors in our body exist in [NCERT Pg. 158]

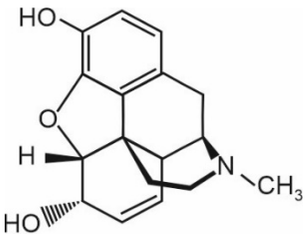
(1) CNS and GIT
(2) GIT and cardio vascular system
(3) GIT only
(4) Cardio vascular and respiratory system

18. Body builders usually abuse steroids to enhance their performance but it also results in following adverse effects **except**

[NCERT Pg. 162]

(1) Enlargement of breast
(2) Facial acne
(3) Premature baldness
(4) Overproduction of sperms

19. How many of the drugs in a box belong to the structure given below? [NCERT 158]



Hashish, Marijuana, Morphine, Charas

(1) One
(2) Two
(3) Three
(4) Four

20. Select the **incorrect** statement

[NCERT Pg. 154]

(1) MALT constitute ~ 50% of lymphoid tissue in human body
(2) Spleen is a large reservoir of erythrocytes
(3) Lymph nodes trap antibodies and are responsible for activation of antigens
(4) Thymus keeps reducing in size with age

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Thinking in Context

1. Lymph nodes and Peyer's patches are _____ lymphoid organs. [NCERT Pg. 154]
2. Interferons make _____ barrier. [NCERT Pg. 151]
3. Antibody exist in colostrum is_____. [NCERT Pg. 152]
4. Total number of peptide chains involved in antibody are _____. [NCERT Pg. 151]
5. T-lymphocytes mediate _____ type of immunity. [NCERT Pg. 151]
6. In response to pathogens, B lymphocytes produce army of proteins called _____. [NCERT Pg. 151]
7. Subsequent encounter with the same pathogen elicits a highly intensified _____ immune response. [NCERT Pg. 151]
8. Rheumatoid arthritis is _____ disease. [NCERT Pg. 153]
9. The principle of immunisation or vaccination is based on the property of _____ of the immune system. [NCERT Pg. 152]
10. Feeding the newborn with yellowish fluid, colostrum secreted by mother during initial days of lactation is an example of _____ immunity. [NCERT Pg. 152]
11. _____ is a bridge linking childhood and adulthood. [NCERT Pg. 160]
12. The most vulnerable phase of mental and psychological development of an individual is _____. [NCERT Pg. 160]
13. Before undertaking any graft/transplant, _____ and _____ matching are essential and even after this patient has to take _____ drugs throughout life [NCERT Pg. 152]
14. _____ is chemically a diacetylated morphine. [NCERT Pg. 158]
15. With repeated use of drugs, the tolerance level of the receptors present in our body _____. [NCERT Pg. 161]
16. Smoking __X__ carbon monoxide content in blood and __Y__ concentration of haembound oxygen. [NCERT Pg. 160]
17. Nicotine stimulates _____ gland to release _____ into blood circulation. [NCERT Pg. 160]
18. *Atropa* and *Datura* plants show _____ properties. [NCERT Pg. 159]
19. Antigen binding sites of antibody are present on _____ terminal of peptide chains. [NCERT Pg. 151]
20. The substances to which there is exaggerated response of the immune system are called _____. [NCERT Pg. 153]

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Strategies for Enhancement in Food Production

Chapter 6

1 ANIMAL HUSBANDRY

Definition:

- Agricultural practice of breeding and raising livestock useful to humans.
- Some of the products and the animals involved are :

Useful products	Source
Milk	Cows, buffaloes, Goats
Eggs	Poultry birds: Chicken, Ducks, Turkey, Geese
Meat	Cattle, Sheep, Pigs
Wool	Sheep
Silk	Silk worms
Honey	Bees

- More than 70% population of livestock is in India and China but contribution to world's farm produce is 25% that result in **problem** ↓
- Productivity per unit is low
- Insufficient food supply due to ever increasing population size.

Solution ↓

- Improvement in conventional practices of animal breeding by applying biological principles.
- Application of newer technologies to Animal Husbandry

Extension of Animal husbandry → **Poultry farming**, **Fisheries**

2 FISHERIES

- Industry devoted to → Rearing, Catching, Processing & Selling of → Fish, Molluscs (shell-fish), Crustaceans (prawns, crabs), Aquatic animals

- **Aquaculture:** Enhancement in aquatic yield including plants and animals
- **Pisciculture:** Increase in total fish yield

Products from fishery

Food : lobster, prawn, fish, edible oyster

- **Fresh water (FW)**: *Catla*, Rohu, Common carp
- **Marine (M)**: *Hilsa*, Sardines, Mackerel, Pomfrets

To meet the increasing demand on fisheries, different techniques have been employed that led to **Blue revolution**

3 MANAGEMENT OF FARM AND FARM ANIMALS

- A professional approach to boost our food production.

Some of the management procedures employed in animal farm system are { Dairy farm, Poultry farm } Management :

1. Dairy farm management/Dairying:

Management of animals for milk and its products for human consumption e.g., cows, buffaloes

Aimed at ↓ **Increasing yield** Depends on ↓ **Quality of breed**

- High yielding potential under given climatic conditions
- Resistance to diseases

led to → **Improving quality of milk**

- **Practices involved**
  - Effective housing
  - Adequate water
  - Maintain disease free conditions → Stringent cleanliness of Cattle, Handlers; Regular inspection by veterinary doctor
  - Cattle diet (fodder) → Quality ↑ (oil cake rich); Quantity balanced

Increased mechanisation in dairy farming particularly milking, storage and transport of milk, reduces chances of direct contact of the produce with the handler

2. Poultry farm management

- Involves use of birds for food → Eggs, Meat
  - Birds : Fowl, chicken, ducks, turkey, geese

- **Practices involved:**
  - Selection of disease free and suitable breeds
  - Proper and safe farm conditions
  - Proper feed and water
  - Maintaining proper health care and hygiene

Disease	Bird flu
Cause	H_5N_1 virus
Symptoms	Respiratory difficulty, fever, malaise
People at risk	• Poultry farmers exposed to infected birds. • People who eats under cooked eggs/poultry

4 BEE-KEEPING (Apiculture)

- It is the maintenance of hives of honeybees for the production of honey
- Age old, high income yield cottage industry and is not labour intensive
- Most common bee in India : ***Apis indica***

Advantages

a. Increases product yield
b. Enhances crop yield

Products obtained from honey bee

- **Bees wax**
  - Preparation of cosmetics and polishes
- **Honey**
  - Food: High nutritive value
  - Used in Indigenous medicine

Salient points for successful bee keeping

(i) Knowledge of the nature and habits of bees
(ii) Selection of suitable location for keeping the beehives
(iii) Catching and hiving of **swarms (group of bees)**
(iv) Management of beehives during different seasons
(v) Handling and collection of honey and beeswax

Bees are effective pollinators

Areas for practice

- **Pastures for shrubs**
- **Crop fields**
  - *Brassica*
  - Sunflower
  - Apple
  - Pear
- **Fruit orchards**

Keeping beehives in crop fields during flowering period increases pollination efficiency and yield

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5 ANIMAL BREEDING

- **Breed :** A group of animals related by descent and similar in most characters like general appearance, features, size, configuration etc.
- **Aims of animal breeding:**
  - Increase the product yield (Quantity ↑)
  - Improving desirable qualities in produce and cattle
    - → High yielding variety
    - → Disease resistant
    - → High reproductive rate
    - → Longer productivity span

6 CONTROLLED BREEDING EXPERIMENTS

Artificial Insemination (AI)	**Multiple Ovulation Embryo Transfer (MOET)**
Identify elite bull	Identify superior cow
↓	↓
Extract semen	Inject with FSH-like hormone
Either used immediately or Cryopreservation (cold storage)	↓
↓	**Super ovulation** (6-8 ova/cycle)
Inject into reproductive tract of superior cow	↓
	AI or natural insemination
	↓
	Non surgical extraction of embryo
	↓
	Gestation in surrogate cow

Advantages

- Greater chances of fertilisation
- Economically relevant as all sperms can be used since semen from 1 bull can fertilise more than 1 cow, if needed
- Helps to overcome several problems of normal mating
- Increase herd size and quality in less time
- Genetic mother available for another round of super ovulation

Disadvantages

- The sucess rate of crossing mature ♂ and ♀ is fairly low
- Not applicable to fishes and birds

7 SELECTIVE BREEDING OR HYBRIDISATION

Types of selective breeding

Inbreeding

- Mating of more closely related individuals within the **same breed** for 4-6 generations
- Inbreeding increases **homozygosity** and is useful to evolve **purelines**

Advantage

- Increases the productivity of population as superior genes are accumulated and harmful recessive genes are eliminated

Disadvantages

- **Inbreeding depression** (ID) due to continued close inbreeding reduces → Fertility, Productivity

Outbreeding

- Mating between male and female of same breed (no recent common ancestor) or different breeds or different species

1. Outcrossing

Mating of animals within the **same breed** but having **no common ancestors** upto 4-6 generations

↓ **Advantage**

- A single out cross helps increase productivity of animals below average
  - → ↑ growth rate in beef cattle
  - → ↑ milk production

2. Cross breeding

- Mating between superior male of one breed and superior female of another breed
- This method allows combination of superior qualities of two different breeds on a commercial scale.

↓ **Advantage**

- Stable new breeds superior to existing breeds can be developed
- **Example**: A new breed of sheep

♂/Male		♀/Female
Merino ram	×	Bikaneri ewe

↓

Hisardale

- **Location :** Punjab

3. Interspecific hybridisation

- Male and female of two **different related species** are mated

↓ **Advantage**

- Progeny may combine desirable features of both the parents and may be of considerable economic value
- **Example:**

♂/Male		♀/Female
Donkey	×	Horse (Mare)

↓

Mule (Sterile)

Inbreeding depression can be overcome by out crossing i.e., method to restore fertility and yield

- MOET is demonstrated on mammals such as cattle, mares, sheep, rabbits
- **Superior cow :** High yield of milk/lactation
- **Superior bull :** Lean meat with less lipid

} Have been bred successfully to increase herd size in a shot time

Sharpen Your Understanding

1. Percentage of world livestock population in India and China is estimated to be [NCERT Pg. 165]
(1) 7% (2) 25%
(3) 70% (4) 17%

2. Embryo transfer technology to enhance food production is applicable to all **except** [NCERT Pg. 169]
(1) Sheep (2) Buffalo
(3) Rabbit (4) Katla

3. Choose the **odd one** w.r.t. habitat [NCERT Pg. 169]
(1) *Hilsa* (2) *Catla*
(3) *Rohu* (4) Common carp

4. Keeping beehives in crop fields during flowering period increases pollination efficiency for many crops. This is **not** true for [NCERT Pg. 169]
(1) Banana (2) Sunflower
(3) *Brassica* (4) Pear

5. Read the given statements
I: Contribution to the world's farm produce from India and China is 25 percent despite very high livestock population
II: Low productivity per unit explains statement I
Choose the **correct** answer [NCERT Pg. 166]
(1) Only statement I is correct
(2) Both statement I and II are true
(3) Only statement II is correct
(4) Both statement I and II are false

6. Select the improved breed of chicken from options below. [NCERT Pg. 167]
(1) Jersey (2) Leghorn
(3) Geese (4) Turkey

7. Category of domesticated birds used for food or for their eggs generally **exclude** [NCERT Pg. 166]
(1) Turkey (2) Geese
(3) Duck (4) Peacock

8. The best method for overcoming reduced productivity due to close inbreeding is [NCERT Pg. 168]
(1) Inbreeding depression
(2) Out-crossing
(3) Cross-breeding
(4) Interspecific hybridisation

9. 'Mule' is a resultant of which category of out-breeding? [NCERT Pg. 170]
(1) Cross-breeding
(2) Interspecific hybridisation
(3) Out-crossing
(4) Inbreeding depression

10. Among following, technique used to develop *Hisardale* is [NCERT Pg. 168]
(1) Interspecific hybridisation
(2) Inbreeding
(3) Cross-breeding
(4) Out-crossing

11. Which of the following are crossed to obtain 'Mule'? [NCERT Pg. 168]
(1) Mare and donkey
(2) Stallion and donkey
(3) Male sheep and female horse
(4) Female sheep and male donkey

NCERT Based MCQs

12. Hormone used to induce follicular maturation during MOET is [NCERT Pg. 168]
(1) LH - like (2) FSH like
(3) Estrogen like (4) GH like

13. Select the **incorrect** match [NCERT Pg. 165]
(1) *Apis indica* – Beeswax
(2) Rearing shell fish – Pisciculture
(3) Bird flu virus – H_5N_1
(4) Inbreeding – increase homozygosity

14. 'Blue revolution' is associated with increase in production of [NCERT Pg. 170]
(1) Milk
(2) Wheat
(3) Eggs
(4) Aquatic products from animals

15. Homozygous purelines of peas were developed by Mendel. Technique involved in doing so is [NCERT Pg. 167]
(1) Out-breeding (2) Inbreeding
(3) Out-crossing (4) Cross-breeding

16. State or city where *Hisardale* was developed is [NCERT Pg. 168]
(1) Punjab (2) Karnal
(3) Haryana (4) Lucknow

17. Apiculture can help to increase all **except** [NCERT Pg. 169]
(1) Honey yield
(2) Crop yield
(3) Fertility of soil
(4) Constituent used in indigenous medicine

18. Which of the following is an improved variety of sheep? [NCERT Pg. 168]
(1) Jersey
(2) Mule
(3) *Hisardale*
(4) Mackerel

19. MOET does **not** involve [NCERT Pg. 169]
(1) Superovulation
(2) Artificial insemination
(3) Use of FSH-like hormone
(4) Gestation in biological mother

20. Select the **mis-match** w.r.t. useful products [NCERT Pg. 169]
(1) Aquaculture – Rearing fish and prawns
(2) Meat – Turkey
(3) Honey – *A. indica*
(4) Eggs – Pomfret

Thinking in Context

1. _____ is the agricultural practice of breeding and raising livestock. [NCERT Pg. 165]

2. Fisheries include rearing, catching, selling of freshwater fishes such as _____ along with crustaceans *e.g.*, crabs. [NCERT Pg. 165]

3. Beekeeping also called _____ is the maintenance of hives of honey bees for production of honey. [NCERT Pg. 169]

4. _____ is a controlled method of herd improvement in short time. [NCERT Pg. 168]

5. In MOET, production of 6-8 eggs per cycle by a cow instead of one is known as _____. [NCERT Pg. 168]

6. During MOET, fertilized eggs at _____ cells stage are non surgically recovered from the biological mother. [NCERT Pg. 169]

7. *Hisardale* is a new breed developed by crossing Bikaneri ewes and Merino _____. [NCERT Pg. 168]

8. _____ aims at increasing the yield of animals and improving desirable qualities of the produce. [NCERT Pg. 167]

9. Avian flu virus is commonly called _____ virus. [NCERT Pg. 167]

10. The countries contributing to 70% of world's livestock population are _____ and _____. [NCERT Pg. 165]

11. Improved breed of cattle and chicken are _____ and leghorn. [NCERT Pg. 167]

12. _____ is a group of animals related by descent and similar in most characters like general appearance, features *etc*. [NCERT Pg. 167]

13. A superior females in case of cattle, is a cow or buffalo that produces more milk per _____. [NCERT Pg. 167]

14. _____ is the management of animals for milk and its products for human consumption. [NCERT Pg. 166]

15. Mechanisation of processes in dairy farming has _____ chances of direct contact of the produce with the handler. [NCERT Pg. 166]

16. Mating of more closely related individuals within the same breed for 4-6 generations is called _____. [NCERT Pg. 167]

17. Continued inbreeding results in inbreeding depression, reducing both productivity and _____. [NCERT Pg. 167]

18. In _____, male and female animals of two different related species are mated. [NCERT Pg. 168]

19. Practice of mating of animals within the same breed but having no common ancestors on either side of their pedigree upto 4-6 generations is _____. [NCERT Pg. 168]

20. Superior males of one breed are mated with superior females of another breed in method called _____. [NCERT Pg. 168]

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Biotechnology: Principles and Processes

7 Chapter

1 INTRODUCTION

- **Biotechnology** deals with techniques of using live organisms or enzymes from organisms to produce products and processes useful to humans.

Parameters	Traditional biotechnology	Modern biotechnology
Organisms involved	Microbes	Genetically modified organisms
Production	Small scale	Large scale
Examples/Technique include	Curd, bread or wine making	*In vitro* fertilisation leading to a 'test -tube' baby
		Synthesising a gene and using it
		Developing a DNA vaccine
		Correcting a defective gene

EFB (European Federation of Biotechnology)

- **'The integration of natural science and organisms, cells, parts thereof, and molecular analogues for products and services'.**
- It encompasses both traditional view and modern molecular biotechnology.

2 PRINCIPLES OF BIOTECHNOLOGY/CORE TECHNIQUES INVOLVED IN MODERN BIOTECHNOLOGY

Parameters	Genetic engineering	Bioprocess engineering
Definition	Techniques to alter the chemistry of genetic material to introduce these into host organisms, and thus change the phenotype of host organism	Maintenance of sterile ambience in chemical engineering processes to enable growth of only the desired microbe/eukaryotic cell in large quantities
Include	Creation of rDNA Gene cloning Gene transfer	Manufacture of biotechnological products like antibiotics, vaccines, enzymes, etc.

The ability to multiply copies of antibiotic resistanse gene in *E.coli* was called **cloning** of antibiotic resistance gene in *E.coli*.

3 ADVANTAGES OF BIOTECHNOLOGY OVER OTHER TECHNIQUES

Methods	Advantage	Disadvantage
I. Asexual reproduction	Preserves genetic information	No variations
II. Sexual reproduction	Provides opportunities for variations and formulation of unique combinations of genetic setup	Some of which may be harmful to the organism as well as the population
III. Traditional hybridisation	Used in plant and animal breeding.	Very often lead to inclusion and multiplication of undesirable genes along with desirable genes.
IV. Genetic engineering	Allows us to isolate and introduce only one or a set of desirable genes without introducing undesirable genes into target organism.	—

4 THREE BASIC STEPS IN GENETICALLY MODIFYING ORGANISMS

(1) Identification of DNA with desirable genes (2) Introduction of the identified DNA into the host
(3) Maintenance of introduced DNA in the host and transfer of the DNA to its progeny

5 KEY TOOLS OF RECOMBINANT DNA TECHNOLOGY

(1) **Enzymes** (2) **Vectors** (3) **Competent host cells**

Enzymes - Most commonly used enzymes in genetic engineering are
- **Nucleases**
- **DNA polymerase**
- **Ligases**

Nucleases - Catalyse the cleavage of nucleic acids.

Types

Exonucleases
Remove nucleotides from the ends of the DNA

Endonucleases
Make cuts at specific positions within the DNA *i.e.* at **recognition/palindromic sequence**

- In the year 1963, the two enzymes responsible for **restricting the growth of bacteriophage** in *Escherichia coli* were isolated

Methylase
Add methyl groups to bacterial DNA

Restriction endonuclease / Molecular scissors
Cut the DNA of bacteriophage

Palindromic sequence reads same on the two strands (from 5′ → 3′ and 3′ → 5′ direction) when orientation of reading is kept same

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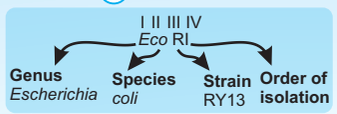
6 ENZYMES

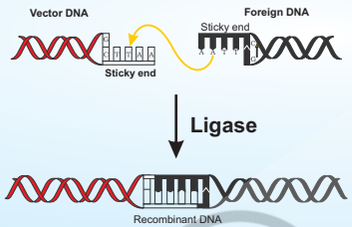
- **Restriction endonuclease**

More than **900** restriction enzymes have been isolated from over **230** strains of bacteria (**prokaryotic cell**) each of which recognise different recognition sequences.

- **Nomenclature/Naming of enzyme :**



- **Functions by:**
  - **'Inspecting'** the length of DNA sequence
  - **Binds** to the **"specific recognition sequence"**
  - **Cuts** the two strands of **ds DNA** at specific points in their **sugar-phosphate backbones** and leaves single stranded portions at the ends.
  - These **overhanging stretches** and called **sticky ends.**



Steps in formation of rDNA

- **Ligase**
  - When source DNA and vector DNA are cut by the same restriction enzyme the resultant DNA fragments have the same kind of 'sticky-ends'. Sticky ends are named so because they form hydrogen bonds with their complementary cut counterparts and this stickiness facilitates the action of the enzyme **DNA ligase**.

- First restriction endonuclease - ***Hind* II :** Isolated and characterised five years later, recognises sequence of **6 bp**.
- First recombinant DNA was prepared by **Stanley Cohen and Herbert Boyer, 1972** :
  - Antibiotic resistant gene
  - Plasmid of *Salmonella typhimurium*

→ Recombinant plasmid —(Introduced into)→ *Escherichia coli*

7 CLONING VECTORS

- **Vectors are vehicles** for delivering foreign DNA into recipient cells.
- Vectors used at present are engineered in such a way that they help **easy linking of foreign** DNA and selection of recombinants from non recombinants

Features of cloning vectors:

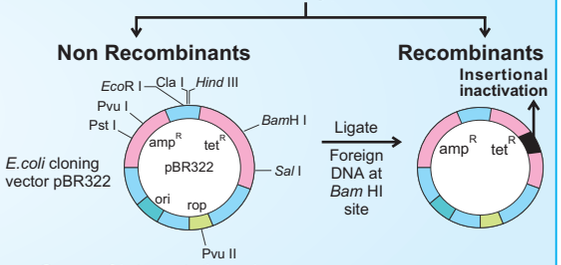
(1) **Origin of Replication (ori):**
- Sequence from where replication starts
- Responsible for **controlling copy number** of the linked DNA
- Those vectors are preferred which support **high copy number**

(2) **Selectable Marker:**
- Helps in selection of transformants
- Normally, the **genes encoding resistance to antibiotics** such as ampicillin, chloramphenicol, tetracycline or kanamycin, etc., are considered useful selectable markers for *E.coli*
- The **normal *E.coli* cells do not carry resistance against any of these antibiotics**

(3) **Cloning Sites/Restriction Sites**
- **Single recognition site** for a restriction enzyme within the vector is a **preferable** feature.
- Presence of more than one recognition sites within the vector will generate several fragments, which will complicate the gene cloning
- The ligation of alien DNA/**gene of interest (GOI)** is carried out at a restriction site present in one of the antibiotic resistant genes.

- **Transformation:** Procedure through which piece of foreign DNA is introduced in a host bacterium.
  - **Insertional inactivation:** Insertion of GOI within antibiotic resistance gene/selectable marker results in inactivation/formation of the coded product.
  - **Hypothesis:** Insertion of GOI at *Bam* HI site in tet^R.
  - If transformation **fails** – Non transformants are obtained in antibiotic lacking agar medium but they don't grow on antibiotic rich medium.
  - If transformation **successful** – **Transformants** obtained are of **two types:**

- **All transformants are not recombinants but all recombinants are transformants.**
- One antibiotic resistant gene helps in selecting the transformants whereas the other antibiotic resistant gene helps in selection of recombinants
- *rop* → codes for the proteins involved in the replication of the plasmid



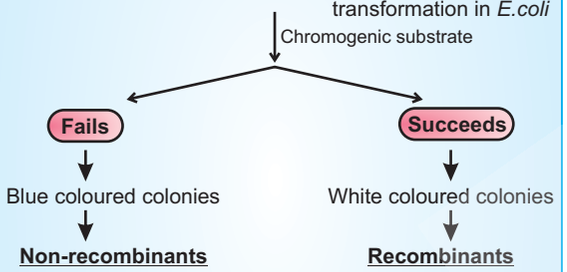
- **Plasmids as vectors:**
  - **Extra chromosomal**, circular, double stranded DNA.
  - Replicate independent of the control of chromosomal DNA (autonomously).
  - They may have 1 or 2 copies per cell or even15 - 100 copies per cell.

9 OTHER CLONING VECTORS

Selection of recombinants due to inactivation of antibiotic resistant gene as in pBR322 is a cumbersome procedure because it requires simultaneous plating of two plates having different antibiotics.

To **overcome the disadvantage of pBR322**, alternative selectable markers (***lac Z***) acting as **reporter enzyme** have been developed which differentiate recombinants from non-recombinants on the basis of their ability to produce colour in the presence of chromogenic substrate.

- *lac* Z gene coding for β-galactosidase acts as selectable marker in the plasmid
- **Experiment:** Insert foreign DNA at *lac* Z gene + transformation in *E.coli*



- **Ti plasmid of *Agrobacterium tumefaciens***
  - *Agrobacterium tumefaciens*, a pathogen of several **dicot plants** is able to deliver a piece of DNA known as '**T-DNA**' to transform normal plant cells into a tumor and direct the tumor cells to produce the chemicals required by the pathogen.
  - **Disarmed tumour inducing (Ti) plasmid** is used which is no more pathogenic to the plants but is still able to use the mechanism to deliver the genes of our interest into varieties of plants.
- **Bacteriophages**
  - **High copy number** than plasmid
- **Retroviruses**
  - Retroviruses in animals have the ability to transform normal cells into cancerous cells
  - **Disarmed retroviruses** are used to deliver desirable genes **into animal cells**

10 METHODS OF TRANSFORMATION

I. Micro - injection
- Recombinant DNA is **directly** injected into the nucleus of an **animal cell**.

II. Biolistic/Gene gun
- **Plant cells** are bombarded with high velocity micro-particles of **gold or tungsten coated with DNA**.

III. Heat shock method

IV. "Disarmed pathogen" vector

11 COMPETENT HOST FOR TRANSFORMATION WITH RECOMBINANT DNA

- DNA is **hydrophilic**, so it can not pass through cell membranes
- In order to force cell to take up alien DNA/rDNA, it must first be made '**competent**' by **treating** with ice cold **calcium chloride**.
- Entry of rDNA in host cell is due to transient pores created by heat shock (42°C) and not due to Ca^{+2} ions.
- Divalent cations **increases the efficiency** with which DNA enters the bacterium through pores in its cell wall.

12 PROCESS OF RECOMBINANT DNA TECHNOLOGY

Isolation of DNA
↓
Fragmentation of DNA by restriction endonucleases
↓
Isolation of desired DNA fragment (**electrophoresis**)
↓
Amplification of gene of interest (**PCR**)
↓
Ligation of the DNA fragment into a vector
↓
Transferring the alien DNA/recombinant DNA into the host
↓
Culturing the host cells in a medium at large scale (**Bioreactors**)
↓
Extraction and **purification** of the desired product

I. Isolation of the Genetic Material (DNA)
- In majority of organisms, DNA is the genetic material
- Since DNA is enclosed within the membranes, we have to break the cell open to release DNA along with other macromolecules → **Bacteria → Lysozyme**; **Fungi → Chitinase**; **Plant** cell → **Cellulase**
- In order to get DNA in pure form (free from other macromolecules), it is treated with different enzymes like RNase, protease etc.

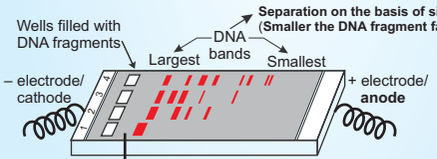
Pure DNA → Centrifuge → **Chilled ethanol to precipitate DNA**

Process: **Spooling**

II. Fragmentation by restriction endonucleases

III. Separation and isolation of DNA fragments
- **Gel electrophoresis**
  - Separation of negatively charged DNA molecules under an electric field through a medium/matrix.
  - Most commonly used matrix for DNA separation is

Agarose → Natural polymer, obtained from **sea weeds**
→ Separate DNA fragments through **seiving effect**



Gel —Stained with→ **Ethidium Bromide** —Exposed to→ **U.V rays** —Appears→ **Bright orange bands** ← Removal of DNA fragment from gel ←Process— **Elution**

- Purified DNA fragments are generally amplified (PCR) before constructing rDNA by joining with cloning vector.

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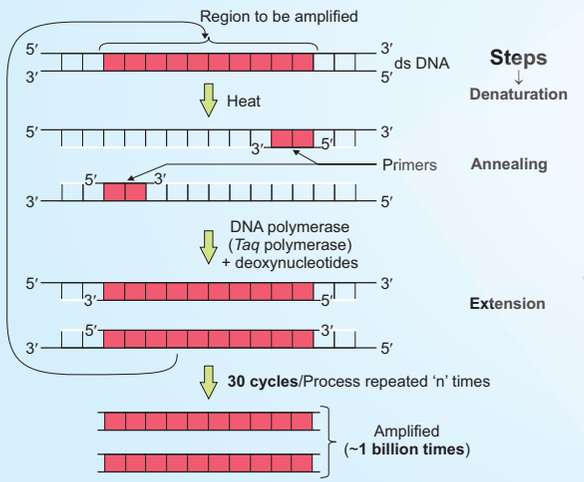
IV. PCR - Polymerase Chain Reaction

- *In vitro* amplification of DNA (gene of interest)

Reaction mixture	Work/Function
Nucleotides	Formation of DNA chain
Primers	2 sets of chemically synthesised oligonucleotides, complementary to the regions of DNA
***Taq* polymerase**	**Thermostable** DNA polymerase, isolated from bacterium, ***Thermus aquaticus***, remains active during high temperature induced denaturation of dsDNA. It extends the primers *i.e.* meant for chain elongation.
Genome DNA	Template DNA for gene of interest

- **Sequence of events**



- The amplified fragment if desired can now be used to ligate with a vector for further cloning.

V. Ligation of the DNA fragment into a vector by DNA ligase

↓

VI. Insertion of recombinant DNA into the host cell

- Transformed host cells are selected with the help of selectable marker genes.

VII. Culturing of recombinant host cells (Biosynthetic stage)

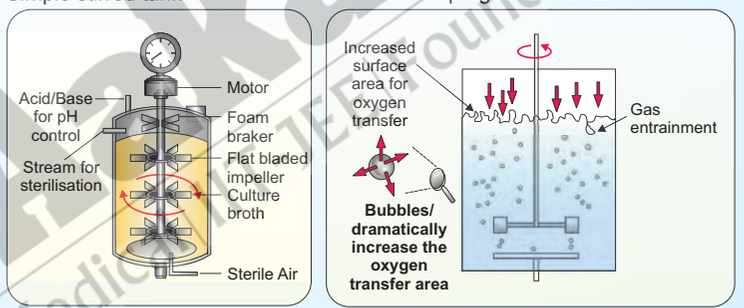
- The cells harbouring cloned genes of interest may be grown in **Laboratory/ Bioreactors**

Parameters	Laboratory	Bioreactors
Culture	Small volume	Large volumes (100 - 1000 lts)
Maintaining optimal conditions	Not possible	✓
Growth rate of cell	Never optimal	Optimum
Production	Small scale	Large scale

- **Bioreactors:** Vessels in which raw materials are biologically converted into specific products using microbial plant, animal human cells and provide optimal growth conditions (temperature, pH, substrate, salts, vitamins, oxygen)

- Commonly used Bioreactors are **stirred type** having
  - Cylindrical or with curved base → Facilitate mixing of reactor contents
  - Stirrer → **Facilitate even mixing** and **oxygen availability** throughout the bioreactor
  - Agitator system
  - Oxygen delivery system
  - pH control system
  - Foam control system
  - Sampling ports → To withdraw small volumes of culture periodically

- **Types of stirred tanks**



In Open Culture System/ Continuous Culture System

- Used medium is drained out from one side while fresh medium is added from the other to maintain the cells in their **physiologically most active log/exponential phase**.
- Larger biomass → Higher yields of desired protein.

VIII. Downstream processing

- **Separation** and **purification** of the desired product/**recombinant protein** from **heterologous host** (non native host).
- Product has to be formulated with suitable **preservatives**.
- **Strict quality control testing** is done for each product
- The downstream processing and quality control testing vary from product to product.

IX. Product is subjected for marketing as a finished product

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Sharpen Your Understanding

1. The definition given by EFB for biotechnology is [NCERT Pg. 193]
   (1) Techniques of using live organisms only
   (2) Techniques of using enzymes only to produce products and processes useful to humans
   (3) The integration of natural science and organisms, cells, parts there of and molecular analogues for product and services
   (4) Techniques which include only synthesising a gene and using it
2. The core technique of biotechnology which involves maintenance of sterile ambience is [NCERT Pg. 194]
   (1) Genetic engineering
   (2) Bioprocess engineering
   (3) Developing a DNA vaccine
   (4) Correcting a defective gene
3. _____ gene codes for the proteins required for the replication of plasmid [NCERT Pg. 199]
   (1) ori (2) rop
   (3) amp^R (4) tet^R
4. Genetic engineering is better over traditional hybridization in [NCERT Pg. 194]
   (1) Introducing desirable genes only
   (2) Introducing undesirable genes
   (3) Introducing both desirable and undesirable genes
   (4) Being easy to perform
5. First recombinant DNA was made by linking **A** with a **B** of **C**. Choose the option which correctly fill the blanks **A**, **B** and **C**. [NCERT Pg. 194]

	A	B	C
(1)	Antibiotic resistant gene	Plasmid	*Salmonella typhimurium*
(2)	Antibiotic resistant gene	Plasmid	*Escherichia coli*
(3)	Antibiotic sensitive gene	Chromosomal DNA	*Salmonella typhimurium*
(4)	Antibiotic sensitive gene	Chromosomal DNA	*Escherichia coli*

6. Restriction endonuclease and methylase were isolated from *E.coli* in the year [NCERT Pg. 195]
   (1) 1972 (2) 1963
   (3) 1997 (4) 1990
7. In *Eco* RI, the letter *R* is derived from [NCERT Pg. 195, 196]
   (1) Genus (2) Species
   (3) Strain RY 13 (4) Strain Rd

NCERT Based MCQs

8. Choose the **odd** one w.r.t. ends produced by *Eco* RI [NCERT Pg. 197]
   (1) Sticky ends
   (2) Single stranded portion on each strand of DNA
   (3) Overhanging stretches on each strand of DNA
   (4) Blunt ends
9. Restriction endonucleases cut which bonds? [NCERT Pg. 196]
   (1) Hydrogen bonds
   (2) Phosphodiester bonds
   (3) Ionic bonds
   (4) Disulphide bonds
10. The separated DNA fragments can be visualised only after staining the DNA with **A** and followed by exposure to **B**. Choose the option which correctly fill the blanks **A** and **B** respectively. [NCERT Pg. 198]

	A	B
(1)	Ethidium bromide	UV radiations
(2)	Bromophenol blue	UV radiations
(3)	Ethidium bromide	Visible light
(4)	Methylene blue	Visible light

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11. The separated bands of DNA are cut out from the agarose gel and extracted from the gel piece. This step is known as [NCERT Pg. 198]
(1) Precipitation (2) Elution
(3) Spooling (4) Fragmentation

12. If we ligate foreign DNA at *Bam* HI site of pBR322, then the resultant recombinants will show [NCERT Pg. 199]
(a) Resistance to ampicillin
(b) Sensitivity to tetracycline
(c) Resistance to tetracycline
(d) Sensitivity to ampicillin
(1) a and b (2) a and c
(3) b and d (4) c and d

13. Recombinant host cells in which foreign DNA is present in the coding sequence of enzyme β-galactosidase will produce [NCERT Pg. 200]
(1) Blue coloured colonies
(2) White coloured colonies
(3) Pink coloured colonies
(4) No colonies

14. Which vector is suitable to deliver desirable genes into dicot plants? [NCERT Pg. 200]
(1) pBR322
(2) Disarmed Ti plasmid of *Agrobacterium*
(3) Disarmed retrovirus
(4) Bacteriophage

15. Complete the analogy w.r.t. DNA isolation Bacteria : Lysozyme :: Fungus : _____ [NCERT Pg. 201]
(1) Cellulase (2) Chitinase
(3) Amylase (4) DNAse

16. All of the following are methods of direct gene transfer **except** [NCERT Pg. 201]
(1) Micro-injection
(2) Biolistics
(3) Gene gun
(4) Disarmed pathogen

17. To make the host cells competent, they are treated with specified concentration of [NCERT Pg. 200]
(1) Ca^{+2} (2) Na^{+}
(3) K^{+} (4) Cl^{-}

18. Which of the following is **incorrect** w.r.t. PCR? [NCERT Pg. 202, 203]
(1) *In vitro* amplification of DNA
(2) Single set of RNA primers
(3) Primers are chemically synthesized oligonucleotides
(4) Thermostable DNA polymerase is used

19. Select the **correct** sequence for the steps involved in PCR [NCERT Pg. 202]
(1) Denaturation → Annealing → Extension
(2) Annealing → Denaturation → Extension
(3) Denaturation → Extension → Annealing
(4) Extension → Annealing → Denaturation

20. What is **not** present in the simple stirred-tank bioreactor? [NCERT Pg. 204]
(1) Foam breaker
(2) Temperature control system
(3) Sampling port
(4) Sparger

Thinking in Context

1. EFB stands for _____. [NCERT Pg. 193]

2. The two core techniques that enabled birth of modern biotechnology are _____ engineering and _____ engineering. [NCERT Pg. 193, 194]

3. _____ sequence is responsible for initiating replication in plasmid. [NCERT Pg. 194]

4. First recombinant DNA was made by _____ and _____ in the year _____. [NCERT Pg. 194]

5. The cutting of DNA at specific locations became possible with the discovery of _____ enzymes, which are also called _____. [NCERT Pg. 194, 195]

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6. The linking of antibiotic resistance gene with the plasmid vector became possible with the enzyme _____. [NCERT Pg. 195]
7. The first restriction endonuclease is _____. Its recognition sequence is _____ long. [NCERT Pg. 195]
8. First letter in the name of restriction endonuclease come from _____ and the second two letters come from the _____ of the prokaryotic cell from which they were isolated. [NCERT Pg. 195]
9. Restriction enzymes cut the strand of DNA a little away from the centre of the palindrome sites, but between the _____ on the opposite strands. This leaves single stranded portions on each strand called _____. [NCERT Pg. 197]
10. DNA fragments are _____ charged molecules that move towards _____ during gel electrophoresis. [NCERT Pg. 198]
11. DNA fragments separate according to their _____ through _____ effect provided by the agarose gel. The _____ the fragment size, the farther it moves. [NCERT Pg. 198]
12. _____ sequence controls the copy number of the linked DNA. [NCERT Pg. 199]
13. *Agrobacterium tumefaciens*, a pathogen of several _____ plants is able to deliver an alien DNA through its _____ plasmid. [NCERT Pg. 200]
14. Disarmed _____ are now commonly used to deliver desirable genes into animal cells. [NCERT Pg. 200]
15. In a method known as _____, recombinant DNA is directly injected into the nucleus of an animal cell. [NCERT Pg. 201]
16. _____ cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA in a method known as _____ or _____. [NCERT Pg. 201]
17. Since DNA is a _____ molecule, it cannot pass through cell membranes. [NCERT Pg. 200]
18. If any protein encoding gene is expressed in a heterologous host, it is called a _____ [NCERT Pg. 203]
19. *Taq* polymerase, a _____ DNA polymerase, is isolated from _____. [NCERT Pg. 203]
20. Separation and purification of desired product in genetic engineering are included in _____ processing. [NCERT Pg. 204, 205]

❑ ❑ ❑

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Biotechnology and Its Applications

8 Chapter

1 INTRODUCTION

- **Biotechnology** : Essentially deals with industrial scale production of biopharmaceuticals and biologicals using GM microbes, fungi, plants and animals.
- **Applications of biotechnology include** :
  - Therapeutics
  - Diagnostics
  - Genetically modified crops for agriculture
  - Processed food
  - **Bioremediation**
  - Waste treatment
  - Energy production
- **Three critical research areas of biotechnology** :
  - **Providing best catalyst** in the form of improved microbes or pure enzymes
  - **Creating optimal conditions** through genetic engineering
  - **Downstream processing** technologies for purification

2 BIOTECHNOLOGICAL APPLICATIONS IN AGRICULTURE

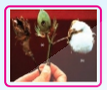
- Food production could possibly be increased by three ways :
  - (i) Agrochemical based agriculture
  - (ii) Organic agriculture
  - (iii) Genetically engineered crop-based agriculture
- **Green revolution** resulted in **tripling** of food production :
  - **Reasons for success of green revolution :**
    - Improved crop varieties
    - Agrochemicals (fertilisers + pesticides)
    - Better management practices
  - **Problem Area and Hinderances :**
    - Enhancement in food production by green revolution was still **not enough** to feed growing population
    - **Agrochemicals** are often too **expensive** for farmers of **developing world**
    - **Increase in yield** with existing varieties is **not possible** using **conventional breeding**

3 INSECT RESISTANT PLANTS

- Provides resistance to insects without the need for insecticides **(bio-pesticide)**
- Examples of biopesticides are **Bt cotton, Bt corn, rice, tomato, potato and soyabean etc.**

Bt cotton

***B**acillus **t**huringiensis* (A bacterium) Source of the ***cry* gene**



↓

Codes for **Bt toxin**

- Produced during a particular phase of their growth
- Inactive protoxins (Protein crystals)
- Endotoxin

Sequence of events

cry gene from *Bacillus thuringiensis*
↓
Bt cotton (Cells express inactive protoxins)
↓
Ingested by cotton bollworms
↓
Alkaline pH in the midgut of insects solubilises protein crystals
↓
Active toxin
↓
Create pores in midgut epithelial cells
↓
Swelling of midgut epithelial cells and thereby lysis
↓
Death of insect

Genetically Modified Organisms

- **Organisms** including plants, bacteria, fungi and animals whose **genes have been altered by manipulation** are called genetically modified organisms **(GMO)**.
- **Applications of genetic modification :**
  - (i) Made **crops more tolerant** to abiotic stresses (cold, drought, salt, heat).
  - (ii) **Reduced reliance** on chemical pesticides **(pest-resistant crops)**.
  - (iii) Helped to **reduce** post harvest **losses**.
  - (iv) Increased efficiency of mineral usage by plants (**prevents early exhaustion of fertility of soil**).
  - (v) Enhanced nutritional value of food, e.g., **golden rice**, i.e., **Vitamin 'A' enriched rice**.
    - **Tailor Made Plants :** Plants have been developed to supply alternative resources to industries in the form of starches, fuels and pharmaceuticals.
- **Choice of gene depends on :**
  - (i) Target pest
  - (ii) Crop
  - *cry I Ac* and *cry II Ab* → Cotton bollworm
  - *cry I Ab* → Corn borer
- **Bt toxins are insect group specific :**
  - **Lepidoptera :** Tobacco budworm, armyworm, cotton bollworm
  - **Coleoptera :** Beetles
  - **Diptera :** Flies and mosquitoes

4 PEST RESISTANT PLANTS

- Method of cellular defense seen in **all eukaryotes** against pest infestation.
- **Technique responsible : RNA interference (RNAi)**

  - Based on **post transcriptional silencing of mRNA**
  - Translation of mRNA coded from pest specific genes is silenced/prevented due to formation of **complementary dsRNA**

↓ source

Viruses with RNA genome | Mobile genetic elements **Transposons** replicating via an RNA intermediate

The case of nematode resistant transgenic tobacco :

- Pest causing **roots knot** disease in tobacco plant : ***Meloidogyne incognita*** (Nematode/helminth)
- **Nematode specific gene** is introduced in **host plant (tobacco)**, by using Ti plasmid (vector) of *Agrobacterium tumefaciens*, in such a manner that it produces both **sense** and **antisense RNA** in the host cells.

↓

- Sense RNA and antisense RNA being complementary form **dsRNA** that **initiates RNAi**.

↓

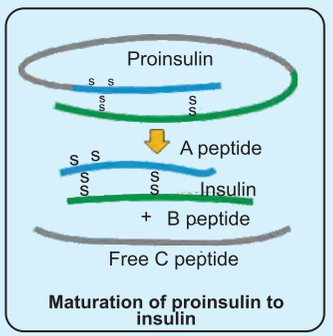
- Parasite could not survive in a **transgenic host** expressing **specific interfering** RNA.

↓

- **Host plant - generated dsRNA triggers protection against nematode infestation**.

5 BIOTECHNOLOGICAL APPLICATIONS IN MEDICINE

- **Advantages of Recombinant Therapeutics :**
  - **30 recombinant therapeutics** have been approved for human use the **world** over. In **India**, **12** of these are presently being marketed.
  - Mass production of safe and effective drugs.
  - Do not induce unwanted immunological responses.
- **Genetically Engineered Human Insulin**
  - **Problem :** Insulin extracted from slaughtered cattle and pigs could cause **allergy**.
  - **Solution :** Production of **humulin**



Maturation of proinsulin to insulin

- **Recombiant insulin** manufactured by **Eli Lilly**, an American company, in **1983**
- The **main challenge** for production of insulin using rDNA techniques was **getting insulin assembled into a mature form**

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Sequence of events :

Artificially synthesised

DNA sequence for A-chain → Plasmid → *E.coli* → Chain A

DNA sequence for B-chain → Plasmid → *E.coli* → Chain B

Produced separately, extracted and combined by creating **disulphide bonds**

Human insulin

Insulin is a peptide hormone and can be degraded by proteases in our gut

6 GENE THERAPY

- Insertion of genes into an individual's cells to treat diseases by
  (i) Replacing a defective mutant allele with a functional one
  (ii) Gene targeting which involves gene amplification.
- **First clinical gene therapy** was conducted in **1990** in a **4 year old** girl to treat **adenosine deaminase (ADA) deficiency**. ADA enzyme is crucial for **immune system** to function

Treatment for ADA Deficiency

(1) Enzyme replacement therapy
- Functional ADA is given by injection] Not completely curative

(2) Bone marrow transplantation in children

(3) **Gene therapy -** Could be a **permanent cure** if bone marrow transplantion is **done at early embryonic stages**.

- Steps in gene therapy

Lymphocytes of patient + ADA cDNA → Retrovirus mediated transformation → Genetically engineered lymphocytes **(not immortal)** → Infused in patient

7 MOLECULAR DIAGNOSIS METHODS

Parameters	Conventional	Modern
Early detection	Not possible	Possible
Examples	Serum and urine analysis	RDT, PCR, ELISA

- **PCR (Polymerase Chain Reaction) :**
  - **Basis :** Nucleic acid amplification
  - **Advantage :** Detection of very low concentration of a bacteria or virus
  - **Uses :** Detection of HIV infection, mutations in genes in cancer patients, genetic disorders
- **ELISA (Enzyme Linked Immuno-Sorbent Assay) :**
  - **Basis: Antigen - antibody interaction**
  - **Uses :** Detect the presence of antigens or antibodies synthesized against pathogens
- **Autoradiography**
  - **Probe :** Radioactive **ssDNA** or **ssRNA** that hybridises with complementary DNA
  - **Probe will not hybridise with mutated gene**, hence mutated gene will not appear on the photographic film due to lack of complementarity.

8 TRANSGENIC ANIMALS

- Possess manipulated DNA and express foreign gene
- Transgenic rats, rabbits, pigs, sheep, cows and fish have been produced
- **95% of transgenic animals are mice**.

Uses of Transgenic Animals

- To study how genes are regulated and how they affect the normal functions of body, *e.g.* study of insulin - like growth factors
- Transgenic models exist for study of diseases like cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's
- Biological products
  - α-**1 antitrypsin** - To treat **emphysema.**
  - Similar attempts are made for treatment of PKU (Phenylketonuria) and cystic fibrosis.
  - **First** transgenic cow : **Rosie** developed in **1997** producing human protein enriched milk (**2.4 grams per litre**)
    - The milk contained **alpha-lactalbumin** : More balanced product for human babies than natural cow milk
- Vaccine Safety
  - **Transgenic mice** are being used to test the safety of **polio vaccine** to replace the use of monkeys.
- **Chemical safety testing**
  - Transgenic animals are made **more sensitive to toxic** substances to obtain results in less time.

9 ETHICAL ISSUES

- Genetic modification of organisms (GMO) can have unpredictable results when such organisms are introduced into the ecosystem.
- Genetic manipulation of living organisms by humans has to regulated for moral and biological significance.
- **GEAC (Genetic Engineering Approval Committee) :** Makes decisions regarding the validity of GM research and the safety of introducing GMO for public services
- Developing countries are rich in biodiversity and traditional knowledge related to bio-resources
- Biopiracy : Refers to the use of bio-resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment.

Controversies regarding patents and biopiracy :

(i) **Basmatic rice :**
- **2,00,000 varieties of rice in India. 27 documented** varieties of Basmati rice in India
- In **1997**, an American company got patent rights on **Basmatic rice** through the **US patent and Trademark office**.

Basmati rice × Semi-dwarf variety of rice → New variety of Basmati rice

(ii) Turmeric

(iii) Neem

The Indian Parliament has recently cleared the **second amendment** of the Indian Patents Bill.

Sharpen Your Understanding

1. GM plants have been useful in many ways **except** [NCERT Pg. 208]
   (1) More tolerant to abiotic stresses
   (2) Pest-resistant crops
   (3) Bio-pesticide plants
   (4) Reduced efficiency of mineral usage
2. Choose the **odd** one w.r.t. Bt toxin [NCERT Pg. 208]
   (1) Insecticidal protein
   (2) Exists as protein crystals
   (3) Exists as inactive protoxins
   (4) Produced continuously during growth period
3. Bt toxin kills certain insects such as tobacco bud worm, army worm etc. These insects belong to which order? [NCERT Pg. 208]
   (1) Coleoptera (2) Lepidoptera
   (3) Diptera (4) Hymenoptera
4. Read the following statements and choose the **correct** option.
   Statement A : Bt toxin gets activated in alkaline pH of insect gut, which solubilises the protein crystals.
   Statement B : Activated toxin binds to the surface of midgut epithelial cells. [NCERT Pg. 208]
   (1) Only statement A is correct
   (2) Only statement B is correct
   (3) Both A and B statements are correct
   (4) Both A and B statements are incorrect
5. The proteins encoded by which gene controls corn borer? [NCERT Pg. 209]
   (1) *cry I Ac*
   (2) *cry II Ab*
   (3) *cry I Ab*
   (4) *Sry*
6. How many applications given in the box below are application of biotechnology?

Energy production, Waste treatment, Bioremediation, Diagnostics

   [NCERT Pg. 209]
   (1) Four (2) Three
   (3) Two (4) One
7. Select the pest resistant plant among the following [NCERT Pg. 209]
   (1) Golden rice
   (2) Flavr Savr tomato
   (3) Transgenic tobacco
   (4) Transgenic *Brassica napus*
8. Which of the following is **incorrect** w.r.t. RNAi? [NCERT Pg. 209]
   (1) Present in all eukaryotic organisms
   (2) Method of cellular defense
   (3) Prevent transcription of the gene
   (4) Involves silencing of specific mRNA
9. Nematode-specific genes were introduced into the tobacco plant by using [NCERT Pg. 209]
   (1) Disarmed Ti plasmid of *Agrobacterium*
   (2) *Meloidogyne incognita*
   (3) *Bacillus thuringiensis*
   (4) Retrovirus
10. Eli Lilly, an American company prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them through a plasmid into [NCERT Pg. 211]
    (1) *Entamoeba coli*
    (2) *Escherichia coli*
    (3) *Salmonella typhimurium*
    (4) *Haemophilus influenzae*
11. Select the treatment method which could be a permanent cure for ADA deficiency in humans [NCERT Pg. 211]
    (1) Enzyme replacement therapy
    (2) Infusion of genetically engineered lymphocytes having functional ADA cDNA
    (3) Bone marrow transplantation after 10 years of age
    (4) Introducing ADA gene into cells at early embryonic stages
12. Which vector was used in the first successful clinical gene therapy in humans? [NCERT Pg. 211]
    (1) *Agrobacterium tumefaciens*
    (2) Retrovirus
    (3) pBR322
    (4) Bacteriophage

NCERT Based MCQs

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13. Early detection of disease is **not** possible by performing [NCERT Pg. 212]
(1) RDT (2) Urine analysis
(3) PCR (4) ELISA

14. Which of the following is **not** correct w.r.t. PCR? [NCERT Pg. 212]
(1) Routinely used to detect HIV in suspected AIDS patients
(2) Used to detect mutations in genes
(3) Used to detect genetic disorders
(4) Antigen-antibody interaction based test

15. Probe is [NCERT Pg. 212]
(1) Radioactive dsDNA
(2) Radioactive dsRNA
(3) Radioactive ssDNA or ssRNA
(4) Non-radioactive dsDNA

16. Transgenic models exist for how many human diseases given in the box below?

Cancer, Cystic fibrosis, Rheumatoid arthritis, Alzheimer's

[NCERT Pg. 213]
(1) Four
(2) Three
(3) Two
(4) One

17. Select the **incorrect** match. [NCERT Pg. 213]

(1)	α-1 antitrypsin	–	Treatment of emphysema
(2)	α-lactalbumin	–	Transgenic cow Rosie
(3)	Safety of polio vaccine	–	Transgenic mice
(4)	Chemical safety testing	–	Transgenic animals are made less sensitive to toxic substances

18. How many approximate varieties of rice are present in India? [NCERT Pg. 214]
(1) 27 (2) 30
(3) 12 (4) 2,00,000

19. Select the **mismatch**. [NCERT Pg. 214]

(1)	Rosie cow	–	1997
(2)	Patent on Basmati rice by an American company	–	1997
(3)	Human insulin production by Eli Lilly, an American company	–	1987
(4)	First clinical gene therapy	–	1990

20. Use of bio-resources by multinational companies and other organisations without proper authorization from the countries and people concerned without compensatory payment is known as [NCERT Pg. 214]
(1) Biopiracy
(2) Biopatents
(3) Bioethics
(4) Bio-resources

Thinking in Context

1. Green revolution succeeded in _____ the food supply but that was _____ to feed the growing human population. [NCERT Pg. 208]

2. Green revolution was partly due to the use of _____ and mainly due to the use of _____ practices and use of _____. [NCERT Pg. 208]

3. Plants, bacteria, fungi and animals whose genes have been altered by manipulation are called _____ [NCERT Pg. 208]

4. Genetic modification has been used to create _____ plants to supply alternative resources to industries. [NCERT Pg. 208]

5. Bt toxin is produced by a _____ called _____ [NCERT Pg. 208]

6. Bt toxin gene has been introduced in many plants, in effect created a bio-pesticide. Examples are _____, _____, _____, _____, _____ and _____ etc. [NCERT Pg. 208]

7. The proteins encoded by the genes _____ and _____ control the cotton bollworms, that of _____ controls corn borer. [NCERT Pg. 209]

8. A nematode _____ infects the roots of tobacco plants. [NCERT Pg. 209]

9. The source of dsRNA could be from an infection by _____ having RNA genomes or mobile genetic elements called _____ that replicate via an RNA intermediate. [NCERT Pg. 209]

10. Nematode could **not** survive in a transgenic tobacco plant expressing _____. [NCERT Pg. 210]

11. _____ recombinant therapeutics have been approved for human use the world over. In India, _____ of these are presently being marketed. [NCERT Pg. 210]

12. Insulin consists of _____ chains, chain A and chain B, that are linked by _____ [NCERT Pg. 211]

13. _____ peptide is **not** present in the mature insulin. [NCERT Pg. 211]

14. The first clinical gene therapy was given in _____ to a _____ old girl with _____ deficiency. [NCERT Pg. 211]

15. ADA deficiency is caused due to the _____ of the gene for adenosine deaminase. [NCERT Pg. 211]

16. A noval strategy adopted to prevent infestation of nematode in tobacco plant was based on the process of _____. [NCERT Pg. 212]

❑ ❑ ❑

17. ELISA is based on the principle of _____ and _____ interaction. [NCERT Pg. 212]

18. _____ of transgenic animals are mice. Transgenic mice are being used to test the safety of the _____ vaccine. If successful and found to be reliable, they could replace the use of monkeys to test the safety of the _____ vaccine. [NCERT Pg. 213]

19. GEAC stands for _____. [NCERT Pg. 213]

20. The Indian Parliament has recently cleared the _____ amendment of the Indian Patents Bill. [NCERT Pg. 214]

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ANSWERS

Class XII

Chapter-1 : Reproduction in Organisms

Sharpen Your Understanding

1. (2)
2. (3)
3. (4)
4. (3)
5. (3)
6. (2)
7. (1)
8. (4)
9. (2)
10. (3)
11. (2)
12. (1)
13. (4)
14. (2)
15. (4)
16. (4)
17. (1)
18. (3)
19. (1)
20. (2)

Thinking in Context

1. Mitotic, Meiotic
2. Heterogametes
3. Unisexual
4. External
5. Parthenogenesis
6. Life span
7. Not
8. Reproduction
9. Growth
10. Budding
11. Sexual
12. Menstrual cycle
13. Seasonal breeders
14. End
15. Hormones
16. Transfer
17. Synchronised
18. Viviparous
19. Zygote
20. Reduction

Chapter-2A : Human Reproduction

Sharpen Your Understanding

1. (3)
2. (1)
3. (3)
4. (4)
5. (2)
6. (2)
7. (3)
8. (4)
9. (4)
10. (3)
11. (3)
12. (4)
13. (2)
14. (4)
15. (4)
16. (2)
17. (3)
18. (2)
19. (4)
20. (1)

Thinking in Context

1. 250, testicular lobules
2. 60
3. Foreskin
4. Accessory, sperms
5. Androgens/testicular hormones
6. 4
7. Interstitial cells
8. Urine and semen
9. Secondary follicle
10. Secondary oocyte
11. Tertiary
12. 200-300
13. Cortex and medulla
14. 2-4; 10-12
15. Cervical canal, vagina
16. 2-2.5°C less than normal body temperature
17. Luteal
18. Menopause
19. Puberty, menarche
20. Labia majora

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Chapter-2B : Human Reproduction

Sharpen Your Understanding

1. (2)
2. (4)
3. (3)
4. (2)
5. (3)
6. (4)
7. (3)
8. (2)
9. (4)
10. (4)
11. (2)
12. (2)
13. (4)
14. (4)
15. (3)
16. (1)
17. (4)
18. (2)
19. (3)
20. (4)

Thinking in Context

1. Fertilization
2. Chorionic villi
3. Zygote
4. Acrosome
5. 8-16
6. Cleavage
7. Inner cell mass
8. 200-300 million
9. First trimester
10. 9 months
11. Prolactin, hPL
12. Estrogen, progesterone
13. Zygote
14. Oxytocin
15. Parturition
16. Colostrum
17. Umbilical cord
18. Placenta
19. 15-20
20. X-mesoderm, Y-ectoderm, Z-endoderm

Chapter-3 : Reproductive Health

Sharpen Your Understanding

1. (3)
2. (4)
3. (2)
4. (4)
5. (3)
6. (4)
7. (2)
8. (1)
9. (1)
10. (2)
11. (1)
12. (4)
13. (2)
14. (1)
15. (4)
16. (1)
17. (2)
18. (2)
19. (1)
20. (4)

Thinking in Context

1. Unprotected
2. 1971
3. Transfusion
4. 15-24 years
5. 2
6. 2000, 6
7. MMR, IMR
8. 18, 21
9. 10 to 17
10. Easily
11. Coitus interruptus
12. Higher
13. Cervix
14. LNG-20
15. 21
16. 72
17. Abdomen, vagina
18. Itching
19. Fertilisation
20. Husband, healthy donor

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Chapter-4 : Evolution

Sharpen Your Understanding

1. (1)
2. (4)
3. (4)
4. (3)
5. (2)
6. (1)
7. (4)
8. (3)
9. (1)
10. (1)
11. (2)
12. (3)
13. (3)
14. (1)
15. (3)
16. (1)
17. (4)
18. (4)
19. (2)
20. (4)

Thinking in Context

1. Light years
2. Evolutionary biology
3. 1953, American, CH_4, H_2, NH_3, water vapours, 800
4. 3 billion years, RNA, protein, polysaccharides
5. 2000
6. Amino acids
7. Gradual, mutations
8. Saltation
9. Reproductive
10. Malay Archipelago, similar, same
11. Branching descent, natural selection
12. Life cycle or life span
13. Small, directional
14. Gene migration, genetic drift, mutation, genetic recombination, natural selection
15. Stochastic, events, mutation
16. 1850s, white winged, 1920s, dark-winged, No variant
17. Adaptive radiation
18. Convergent evolution
19. 1
20. Directional

Chapter-5A : Human Health and Disease

Sharpen Your Understanding

1. (3)
2. (4)
3. (3)
4. (3)
5. (3)
6. (4)
7. (2)
8. (3)
9. (4)
10. (1)
11. (1)
12. (2)
13. (1)
14. (3)
15. (1)
16. (1)
17. (1)
18. (2)
19. (2)
20. (3)

Thinking in Context

1. Contact inhibition
2. Metastasis
3. Lung
4. Cellular/proto-oncogenes
5. Biopsy
6. α - Interferon
7. NACO
8. ELISA
9. *Toxoplasma*
10. Congenital
11. Body fluids
12. Reverse transcription
13. Intravenously
14. RNA
15. Food and water
16. Elephantiasis/Filariasis
17. Haemozoin
18. Pathogens
19. Pneumonia
20. Smallpox

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Chapter-5B : Human Health and Disease

Sharpen Your Understanding

1. (3) 2. (2)
3. (4) 4. (3)
5. (2) 6. (2)
7. (4) 8. (2)
9. (1) 10. (2)
11. (1) 12. (4)
13. (3) 14. (3)
15. (4) 16. (2)
17. (1) 18. (4)
19. (1) 20. (3)

Thinking in Context

1. Secondary
2. Cytokine
3. IgA
4. Four
5. Cell mediated
6. Antibodies
7. Anamnestic/secondary
8. Autoimmune
9. Memory
10. Passive
11. Adolescence
12. Adolescence
13. Tissue, Blood group, immunosuppressant
14. Smack
15. Increase
16. X-Increases, Y-decreases
17. Adrenal, Adrenaline
18. Hallucinogenic
19. N
20. Allergens

Chapter-6 : Strategies for Enhancement in Food Production

Sharpen Your Understanding

1. (3) 2. (4)
3. (1) 4. (1)
5. (2) 6. (2)
7. (4) 8. (2)
9. (2) 10. (3)
11. (1) 12. (2)
13. (2) 14. (4)
15. (2) 16. (1)
17. (3) 18. (3)
19. (4) 20. (4)

Thinking in Context

1. Animal husbandry
2. Rohu
3. Apiculture
4. MOET
5. Superovulation
6. 8-32
7. Rams
8. Animal breeding
9. H_5N_1
10. China and India
11. Jersey
12. Breed
13. Lactation
14. Dairying
15. Reduced
16. Inbreeding
17. Fertility
18. Interspecific hybridization
19. Out-crossing
20. Cross-breeding

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Chapter-7 : Biotechnology: Principles and Processes

Sharpen Your Understanding

1. (3)
2. (2)
3. (2)
4. (1)
5. (1)
6. (2)
7. (3)
8. (4)
9. (2)
10. (1)
11. (2)
12. (1)
13. (2)
14. (2)
15. (2)
16. (4)
17. (1)
18. (2)
19. (1)
20. (4)

Thinking in Context

1. European federation of biotechnology
2. Genetic, bioprocess
3. Origin of replication
4. Stanley Cohen, Herbert Boyer, 1972
5. Restriction, 'molecular-scissors'
6. DNA ligase
7. *Hind* II, 6 bp
8. genus, species
9. Same two bases, sticky ends
10. Negatively, Anode
11. size, sieving, smaller
12. *ori*
13. Dicot, Tumour inducing (Ti)
14. Retroviruses
15. Micro-injection
16. Plant, Biolistics, Gene gun
17. hydrophilic
18. Recombinant protein
19. Thermostable, *Thermus aquaticus*
20. Downstream

Chapter-8 : Biotechnology and Its Applications

Sharpen Your Understanding

1. (4)
2. (4)
3. (2)
4. (3)
5. (3)
6. (1)
7. (3)
8. (3)
9. (1)
10. (2)
11. (4)
12. (2)
13. (2)
14. (4)
15. (3)
16. (1)
17. (4)
18. (4)
19. (3)
20. (1)

Thinking in Context

1. Tripling, not enough
2. Improved crop varieties, better management, agrochemicals
3. Genetically modified organism (GMO)
4. Tailor-made / transgenic
5. Bacterium, *Bacillus thuringiensis*
6. Bt cotton, Bt corn, rice, tomato, potato, soyabean
7. *cry I Ac, cry II Ab, cry IAb*
8. *Meloidogyne incognita*
9. Viruses, transposons
10. Specific interfering RNA
11. 30, 12
12. Two short polypeptide, disulphide bridges
13. C
14. 1990, 4-year, adenosine deaminase (ADA)
15. Deletion
16. RNAi
17. Antigen, antibody
18. 95%, Polio
19. Genetic Engineering Approval Committee
20. Second

❑ ❑ ❑